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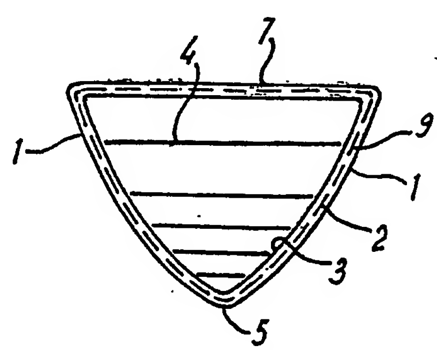

(57) Abstract

A method of construction of an article wherein an inflatable envelope (3) of gas-permeable material has an outer layer (2) of expandable reinforcement and is then inflated to attain a desired shape, whereafter a crating of settable material (9) is applied to at least part of said reinforcement and allowed to harden about said reinforcement to produce a rigid skin over at least said part of the article.

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Reinforced articles and method of their manufacture by means of inflatable moulds.

This invention relates to a method of construction of various products by means of an inflated mould.

Until now the time spent in constructing a new type of leisure yacht whether sailing or motor, monohull or multihull has been to a large extent dependent on the time required to manufacture the mould.

The cost of construction is also dependent on the cost of the mould and as cost is also directly related to man hours spent in manufacturing that product, the more complicated the mould the more costly.

As the numbers of products obtained from that mould increase the price per product decreases, but in many instances the numbers required are few per design, so the largest single factor in cost is often the mould.

This also true of other products particularly in the marine industry, but also in the construction industry, in the aviation industry and in other industries where the numbers of products per design are minimal such as in prototype vehicle manufacture etc. Until now D.I.Y. has hardly touched the marine industry because of the initial problem of constructing the outer shell of the vessel, and usually the shell is itself sold to the D.I.Y. enthusiast who then finishes the product. The construction techniques of using these moulds is also dependent on the material used, and in the case of GRP., Kevlar, Carbon fibreglass or combinations of

these products the mould has a release agent brushed or otherwise applied to the surface before the GRP etc. is laid up, whereas in the construction industry if a continuously inflated membrane is used the material usually does not need a release agent and after the membrane has concrete blown over it, the pressure is released and the membrane drops down and is taken out of the building. Until now the membrane has seldom been left as part of the construction, and by inflating it in the manner described, the shapes which can be constructed are limited to being spherical or oblong because there is no internal membrane with struts to keep a particular shape.

Until now an inflated tent, marquee or other type of building has mainly used the system of inflating permanently because of the difficulty and cost of constructing a second skin system with internal struts (or ribs) and also because of the vulnerability of the latter system should someone wish to vandalise it by cutting the outer or inner skin with a sharp object.

Because of the smaller volume of air between the two skins the building would collapse without an emergency supply of air, possibly trapping people inside, and in the case of fire the potential conflagration could be disastrous for those inside.

Until now it has also been extremely difficult logistically as well as being time consuming at the other end, to construct bridges over rivers, lay a road over marshy ground or desert or to construct such items in an emergency

situation whether for civilian or military purposes.

Until now it has also been difficult for the Special Boat Squad or Royal Marines to carry a device which could transport them over water or possibly over snow and land without that product weighing a considerable amount or being too bulky to carry.

In greenhouse construction until now it has not been possible to manufacture a simple double skinned inflated building which was semi permanent and yet was thermally more efficient than the glasshouse type presently available.

Even in the airship industry the costs of manufacturing a rigid airship have been extremely high until now and the method of construction was very time consuming.

The invention provides a method of constructing an article comprising: providing an inflatable envelope of which at least a part is of flexible sheet material, and to at least a portion of whose outer surface is secured a layer of expansible reinforcement material; inflating the envelope; applying a settable material to said portion of said outer surface in a fluent state; and allowing said settable material to harden about said reinforcement material.

The article to be constructed can be composed of polyurethane or some such similar thermoplastic material which is laminated either directly to glass fibres, Carbon fibreglass, Kevlar or a mixture or combinations of these fibrous materials or is laminated to a further skin such as nylon before being laminated to the glass fibres, Carbon fibreglass Kevlar or a mixture or laminations of these

materials, before being rendered rigid by the addition of by way of example an epoxy resin, a polyurethane resin, or other chemical which preferably reacts with the base material. It is possible with certain laminations such as polyurethane, or some such similar thermoplastic elastic material, and chopped strand glass fibre to obtain a skin which is elastic in order to create special shapes while with an inelastic material such as polyurethane/nylon/woven glass fibre etc. the material would have to be cut very carefully in order to create that same shape.

It is further possible with this invention to allow one skin to harden and then to add if necessary other skins to make the product thereof more permanent and stronger.

This invention enables one or more further skins to be added conventionally or by an internally inflated second or third skin etc. which can if necessary have a lamination or pressure sensitive adhesive method of fixing one skin to the other. These secondary skins may not necessarily be of the same material as the first skin.

An internally ribbed product with a double skin can be inflated within the two skins to have if required one skin become rigid to act as the frame or outer or inner cladding which would be vandal proof, while the other skin acts in the same way as a cushion in that it can be stretchable or non stretchable with a high or low pressure to give the most comfort, such as is required with a seat.

Certain parts of a single skin structure can be caused to become hard (or rigid) whilst other parts can remain

unhardened or can if required be cut out to form doorways, windows etc. with less problem than if they were hardened.

Articles can be finished on site with the least possible time delay, mess and construction equipment, and in the simplest form the method will only require a method of inflating the product, a single or two part resin, or glue, a roller or brush, and if required a finishing sanding system, whereas in the more sophisticated systems the resin can be blown over the product with or without chopped strand fibreglass etc. as required to increase the strength of the product before finishing it off or adding second or third skins etc.

The membrane which becomes a hard or rigid skin can by way of example be used as a transport module or environmentally safe cargo container by adding the resin or epoxy after inflating the container on site, whereas the container can be transported and stored in an uninflated or packed state thereby saving space and cost. The cargo can either be inserted before or after the product becomes rigid depending on its shape, and the shape required for ease of handling, and in the former case it is a further object of this invention that a novel method of heat sealing can be employed at site to seal the container before inflation. Site offices can be transported in a packed uninflated state to be blown up and made rigid on site.

It is possible to incorporate ribs composed by way of example of composities of glass fibres, carbon fibreglass , Kevlar or combinations thereof or plastics such as

polycarbonates or metals such as aluminium, in the membrane of the product to give extra strength by sealing them into or affixing them to the inner or outer skin. By this means the article, which could be by way of example a structure such as a vessel, site office or container etc. can be packaged in an uninflated form, but with or without internal stretchable or non stretchable membranes used as struts it could still be inflated to a particular shape whilst having greater strength than without the ribs.

These ribs could be in the form of tubes or solid structures which are preshaped to take up the shape required when inflated and yet when packaged they would not take up nearly the same space as a completed structure.

These ribs could alternatively themselves be manufactured by the same process as the main process and they could also be packaged separately to the main membrane but the main membrane could be constructed in such a way that these ribs after construction could be slid into by way of example preformed pockets again saving space. Once inflated these ribs would be held firmly in place by the pressure created and once resin had been added they would be locked in place.

A small packaged object can become by way of example a mast or complete jury rig for use in an emergency at sea. In the same way a rudder could be constructed in an emergency at sea by taking a package containing an inflatable rudder, a resin and a pump.

This invention enables permanent or semi permanent

bridges and vehicle or pedestrian surfaces for marshes and deserts to be constructed on site again merely by unpacking a pre-shaped, uninflated product or products which when inflated became part or the complete bridge or vehicle surface by the addition of a chemical or epoxy to that skin.

In the same way it would be possible for leisure, military or commercial purposes to construct a vessel or vehicle where required by the same process in the minimum of time, effort and logistical support, and by way of example a small dinghy or catamaran could be carried in a special knapsack to be inflated and if required hardened to form a stronger shell, as could land vehicles.

A renaissance in airship and aerodynamic balloon technology is now taking place and a further object of this invention is to enable more aerodynamic shapes to be constructed which can have hardened outer skins of very low weight because of the internal pressure of lighter than air gas which enable that airship not only to fly at faster speeds but to be lighter than a conventional rigid airship and therefore capable of lifting heavier loads with the equivalent volume of lighter than air gas whilst still retaining the same rigidity as a conventional rigid airship by using the helium as a pressure system against the skin. A direct result of this invention is to lower the cost of such a product in relation to its loading capacity and to enable the airship (if required) to be transported in an uninflated form to the site of permanent use before rendering it rigid.

This invention enables a rigid version of my

contra-rotating flying saucer as described later to be constructed in order to enable it to fly at a faster speed by revolving the contra-rotating inflated envelopes at a higher speed than would be possible with non-rigid envelopes and this would be achieved with a minimum of weight penalty because the internal pressure could be increased giving more volume or allowing the contra-rotating saucer as well as airships to operate at a higher altitude than would be possible without an internal ballonet.

Peripheral winglets and rudders of the contra-rotating flying saucer can also be more firmly affixed to the envelopes because of the rigidity of those envelopes and in the case of the airship or lighter than air aeroplane or inflated aeroplane the rigidity of the envelope enables lighter attachments for landing gear and other hardwear etc. to be used thereby probably lessening the all up weight of the craft, and this factor is also true of vessels such as catamarans or trimarans where the attachments could be built into the main hulls for the beams connecting the hulls.

Where the heat sealable or weldable material is joined 'in peel' one skin can be cut on the outside of the weld and the other skin can be laid across the weld before adding the epoxy in order to create the equivalent of a butt weld which is stronger.

Alternatively both skins can be cut neatly and a layer of glass fibres, kevlar etc. can be laid across the 'peel' joint so created, which will contain a higher pressure but will not be as smooth.

It is a further object of this invention that the structure so created can be by way of example a pressure container or as another example of a vessel which has a considerable internal pressure, giving it more rigidity than without inflation, and this in the latter case is particularly suitable for construction of multihulls, bridges and other systems which are finished in an inflated form rather than being cut in places to allow ingress such as for housing or wearhousing modules.

It is a further object of this invention that whenever a permanently inflated system is constructed the necessity of multiple skins is reduced because of this internal pressure and therefore total weight is reduced considerably without reducing rigidity. This is particularly important for airships, contra rotating flying saucers etc., but is also important for transporting goods to their ultimate destination.

It is a further object of this invention that instead of a lamination of polyurethane and kevlar etc. as had been discussed before, a product can by way of example be manufactured in polyurethane or Pu/nylon etc. without lamination to kevlar, glass fibres, etc. and thereafter rendered rigid by the addition of a kevlar cloth etc. which then has resin or epoxy added. Thereafter further skins can be added of suitable materials as required.

It is a further object of this invention that particularly where a product has to be constructed in a short time or within a confined space the lamination of by way of

example polyurethane/kevlar can before inflation be dipped into a tub or container of some sort of epoxy etc. which reacts more slowly than normal so that after dipping the product can be blown up before it becomes rigid. An example of this could be that a second or third skin etc. is added to a vessel from inside a previously constructed outside skin.

Another object of this invention is to enable a product such as a radar reflector to be constructed out of metallised, eg silvered or aluminised nylon mesh (such as is commonly used by Chemring) within an outer sphere which could by way of example be manufactured from an elastic polyurethane/chopped strand glass fibres laminate which on inflation became an extremely accurate tetrahedral or octohedral and which could then be rendered rigid by means of an epoxy resin. In the deflated form it would take up very little space and yet when sold to a yachtsman it could be quickly and easily erected either permanently or temporarily as required, and by way of another example it could be incorporated within an aerodynamic balloon to fly above a vessel in a more stable manner than on its own even if filled with helium. One of the main objects of this invention is to enable inflated sections to be created which can vary in diameter and shape by means of the relatively simple process of inflating to a certain pressure, epoxying or otherwise chemically treating part of the inflated section and allowing it to dry thereby rendering that part rigid, whereupon the inflation pressure is raised which then inflates the rest of the structure to a greater volume and therefore diameter

which can in turn be hardened.

Part or all of the rest of the product can be dealt with in the same way but by way of example in a Magnus Rotor the top uninflated half could be retracted when required into a hardened wider lower section or the central section of a multihull hull could receive deflated end sections giving a semi-rigid, but more convenient (than totally rigid) product for these purposes. An ideal material for this process is polyurethane which can either be laminated to an extensible material such as chopped strand glassfibre or if polyurethane is used on its own, kevlar or GRP or carbon fibreglass or combinations of these can be laid onto each section as required before epoxying the surface.

Apart from Magnus Effect Rotors and other similar applications this method can be used by way of example for D.I.Y. toys, learning systems for children and building systems, such as tubes with varying diameters which can have altered diameters as required throughout the length of the tube without altering the strength at any one point after completion simply because once inflated it can be covered with glass fibres etc. which can by way of example vary in thickness according to the diameter along the tube to take into account the greater pressure at the widest diameter.

In the same manner by way of example an asymmetrical wing with a particular profile can be constructed even though the laminated skins are heat sealed in a symmetrical section, or possibly with an extensible material in a parallel section, thereby reducing considerably the cost of

manufacture.

Although by way of example the laminations given are polyurethane/GRP/carbon fibreglass/kevlar or combinations or laminations of these, the invention is not limited to these and by way of example any heat sealable, high frequency weldable, gluable, sewable, vulcanised or otherwise thermally seamable material could be used as the base material and any other material which was rendered rigid by some chemical, liquid or other means could be substituted for the glass fibres etc. and by way of example a latex substrate could be vulcanised and plaster or paris could be added after inflation and fixed by means of water to form a rigid tube or product and just as plaster of paris is used for fractures of limbs, it is a further object of this invention that this lamination or the Pu/kevlar/GRP etc. lamination could be of benefit for the same purpose but in this particular case the cast would not be blown up, but would be wrapped around the limb and rendered rigid by means of water or epoxy respectively.

A further alternative example is of a CFRP tube manufactured by this method which gives an extremely light weight but rigid structure with a smooth bore inside because of the polyurethane or other thermoplastic substrate. It can be manufactured in virtually any continuous length and providing it is non extensible at inflation it will form an accurate pipe weighing much less than any conventional pipe with the same strength. This same structure can by way of example be used as a frame for products such as bicycles.

A further object of this invention is to enable a comparatively small uninflated package to be inflated whereupon a technique similar to that used in Lettraset is used on the inside or the outside of the skin in that the encapsulated chemical, resin or epoxy is released by the pressure caused when the inflated skin contacts a hard surface such as in the case of a multiple lay-up of GRP etc. when the second internal skin meets the first hardened outer skin, or alternatively the encapsulated chemical by way of example is released as the inflated skin expands to a certain degree thereby breaking the capsules or a combination of these systems can be used.

In both cases the chemical, resin or epoxy by way of example reacts on the GRP or kevlar etc. and renders an inflated product rigid. This could have particular application in Space, defence and in the process of laminating more than one skin to each other as well as in the D.I.Y. trade as described beforehand. A pre-prepared system using encapsulated resin or a triggerable system can be triggered by pressure, U.V. light, solar energy, salt water or any other convenient trigger mechanism causing the product to inflate and rigidify when certain conditions arise.

In the particular case of Space and Defence, a system of firing or otherwise deploying a system could be achieved with less logistical support and at less cost than a conventional system, and by way of example it should therefore be possible to take a deflated and packaged space station either as one complete system or in parts to be

inflated and fixed together in space. A further example would be a mirror or relay station which could be constructed to be extensible to form an accurate and low cost system, possibly with amorphous silicone solar array panels already incorporated by laminating to the kevlar/carbon skin so that by way of example encapsulated resin or epoxy can be activated by the pressure between the amorphous silicone and kevlar/carbon skin caused by inflation. In all these cases the radar signature of the system(s) could be less than conventional systems, whilst at the same time being less fragile because of the inherent strength gained by the inflated pressure and by way of further example a metal ceramic composite could be used rather than the kevlar/carbon woven material.

Another object of this invention is to seam a thermoplastic zip commonly referred to as a 'Maxigrip' to a rigid as opposed to a supple product in order to create a method of entering the product and by way of example a container could have such a system to pack or unpack the products inside. A further object of this invention is to enable by way of example a Magnus Effect Rotor to be constructed in such a way that the top $^2/_3$ of the rotar can be deflated and retracted within the lower section which remains rigid. If necessary it is still capable of being rotated in high winds to help stabilise the craft whilst not producing the same thrust as when fully extended. It is also capable of being lowered sufficiently whilst passing under bridges etc.

A further object of this invention is to enable complete tyres and wheels to be manufactured in one unit as opposed to a separate tyre and wheel in that it will be possible to place two laminates by way of example, of kevlar and polyurethane material face to face with the kevlar on the outside and to seam the two together by heat, high frequency gluing or sewing back taping in the form of a tyre and wheel and particularly if a very light weight cloth is used for the tyre part the epoxy can be such that the tyre still is supple enough for comfort and the inner core (wheel) could then have other layers of GRP or kevlar or carbon or combination weaves laid on top of the lightweight kevlar to make that portion more rigid than the outer tyre section.

The inner core (wheel) section could either be left uninflated or could particularly in larger wheels be inflated and a tube in between the two outer skins to take the drive or freewheel shaft could be inserted before finally sealing it in order to spread the load. This type of wheel would be of particular use in larger versions and its light weight would be very advantageous in a number of marsh or soft desert sand conditions. Outside treads where necessary could be added at a later stage or could be incorporated as ribs in a similar fashion to the containers. A major object of this invention is to reduce weight without reducing strength, and particularly in Space where pressurised nose cones are already part of the state of art, a system of laminating a seamable material such as polyurethane by way of example to a material such as kevlar or carbon/kevlar woven material is of

considerable advantage particularly when that laminate is heat sealable by a method which can seam long and complicated curvatures on 2 dimensions to result in a 3 dimensional product.

By way of example a project called Spacelab II advocates a small orbiter whose empty weight is estimated to be in the order of 6.1 tonnes of which the shell is estimated to be 2.5 tonnes when manufactured by conventional means, but by using this invention that weight could be reduced to 500 kilos maximum if 60 gm woven kevlar was laminated to 1½ thous polyurethane. By way of example of the pressures possible within such a vehicle an epoxied bottle of 0.34 metres x 0.10 metres has been inflated to over 3° using those materials without bursting and was not able to be distorted in any way by hand. Considering that the proposed orbiter is protected from air loads during the boost phase by partially burying it in the booster, it is possible to use this invention to maximum advantage to reduce unnecessary weight in order either to increase passenger/cargo payload or to increase fuel capacity to enable longer duration flights to occur.

This invention using the same technique of an internally pressurised body must therefore have considerable relevance in other fields of defence such as rockets and projectiles of various sorts, even armoured vehicles, and the system of manufacturing a bullet proof tyre such as has already been shown with kevlar has considerable benefit to vehicles of any sort used in defence.

It is a further object of this invention to show that the method of manufacture is of particular importance if the full exploitation of the sytem can take place. Typically the invention will consist of, although it is not limited by, a two core mineral insulated round heating cable with a copper, cupro-nickel or inconel sheath, which is further surrounded by a copper or preferably silicone sheath to increase thermal conductivity. The element can be fixed in place to a backing plate or piece of material on a platten by means of a fixing glue, such as a Loctite 384 (again silicone based) which is both thermally conductive and electrically insulating. Both the silicone sheath and the fixing glue tend to stop 'Hot Spots' which can cause burns or non sealing in the material which is the major cause of leaks in an inflated product.

The backing plate or material used on the platen to which the element is fixed should be a reflective material to reflect the heat generated by the element back at the material to be welded rather than to dissipate the heat in the platten. A material that could be used for this purpose is commonly called 'Elephant Hide' which is used for high frequency welding purposes.

This element is particularly suitable for the inflated products described beforehand, although not necessarily limiting the invention to those products because it can be manufactured in any length, typically up to 90 metres, and in various diameters, typically from 3mm to 7mm and the wattage per metre can be adjusted by a simple voltage regulator,

therefore allowing both AC and DC current to be used.

A further most important advantage of this invention is that the element can be bent on a single and two dimensional curvature to give a 3 dimensional product which is virtually impossible with a flat wire element or rollers as are used in conventional heat sealing technology.

A further advantage of this invention is that the system is extremely tolerant and by way of example a variation typically between 110-120 watts per metre of weld run using a 5mm electrical element is allowable to heat seal a poyurethane material.

Because the power source can be AC or DC the invention can be used indoors in a purpose built factory or by way of example outdoors on inflated containers, silage clamps and other situations where the product needs to be packaged before finishing the seal, or in situations like in the under developed countries where electricity is not freely available everywhere.

By way of example of a simple curvature heat seaming system the tyre and wheel combination can be seamed in one pass after affixing the valve and central tube to take the power shaft (by either heat sealing or high frequency welding) in approximately 40-80 seconds depending on the size of wheel, and therefore length of element, and the material used in its construction. Although of particular use on single or 2 dimensional products the invention is not limited to that and can also seam straight lines as well, but with the added advantage that they can be as long as required up

to the maximum manufactured length (typically 90 metres) with one element, but with multiple elements any length can be seamed on straight line, single and 2 dimensional curves.

The invention will be described further by way of example with reference to the accompanying drawings wherein:-

Fig. I is a perspective view of a monohull with internal ribbing.

Fig. II is a view taken of the line A-A in Fig. I.

Fig. III is a catamaran showing the areas that would be rendered rigid and other areas that could be cut out to enable ingress to the catamaran hull or the subsequent installation of windows, doors etc.

Fig. IV is a section through B-B in Fig. III.

Fig. V is section through C-C in Fig. III.

Fig. VI is a domed single skin inflatable home used as a former or as the outside shell of the house.

Fig. VII is a plan view of Fig. VI.

Fig. VIII is a section through D-D in Fig. 1 showing multilayer skin technique.

Fig. IX is a Magnus Effect Rotor showing the technique of increasing the diameter at the position above the rotating hub because of the extensible material and method used in its construction.

Fig. X is a double skinned inflatable tent or greenhouse which is subsequently rendered partially or completely rigid.

Fig. XI is a chair rendered partially rigid to form

the base whilst at the same time retaining the flexibility required for comfort by inflating between the membranes to any required pressure.

Fig. XII is a container showing the ribs needed to strengthen the side walls.

Fig. XIII & XIV are methods of joining these ribs.

Fig. XV is an inflatable rudder and Fig. XVI consists of 3 sections through the rudder in Fig. XV.

Fig. XVII is a plan view of a bridge.

Fig. XVIII is a section through H-H in Fig. XVII.

Fig. XIX is a perspective view of the bridge in Fig. XVII.

Fig. XX is a perspective view of an inflated remotely piloted vehicle without a rigid outer skin.

Fig. XXI is the same RPV with a rigid outer skin showing the savings in weight on the attachment systems for engines, rudders and undercarriage.

Figs. XXII-XXIV show the method of making a stronger seam when the initial seam is sealed on 'peel'.

Figs. XXV-XXVII show an example of how an inflated tube can be pressurised differently to achieve different diameters and how a second skin is required at the widest diameter to increase strength at that point.

Figs. XXVIII-XXIX show a radar reflector within a sphere in its packed state and then in its inflated state.

Fig. XXX shows that sphere containing the reflector in an aerodynamic balloon or inflated aeroplane.

Figs. XXXI-XXXVI are examples of the method of

rendering the product rigid by single and multiple skins.

Fig. XXXVIII shows a typical element such as is used to seam the materials by heat sealing.

Figs. XXXVIII & XXXIX are a cross section and longitudinal section respectively of a heating element showing 2 pieces of material laid face to face before seaming commences.

Fig. XL shows an example of a DC seaming system.

Fig. XLI shows a DC seaming system operating on a container to seal the envelope after the products are containerised before inflation.

Fig. XLII is the method of heat sealing a combined tyre and wheel.

Fig. XLIII shows a typical tyre and wheel combination when inflated.

A preferred method of manufacturing the products is shown typically in Fig. 1 in that a vessel, a monohull, consists of an outer skin (1) which is itself composed of 2 or more materials which are laminated together, one of which in this example is outside skin (2) of glass fibre or chopped strand fibre and an inner skin (3) of polyurethane or some other thermoplastic material.

Sheet like restraining members (4) struts of a thermoplastic material such as polyurethane are laid in between 2 outer skins (1) and sealed to the inner thermoplastic material and restrain expansion of the envelope to take the shape required when the vessel is inflated.

There can be as many struts as required in order to form the required shape, but in general the distance between the struts (4) should not be greater than the width of the product at that section.

Once the struts (4) have been sealed to each skin (3) the two skins are sealed along the keel and bow area (5) and a stern section (6) sealed before the deck section (7) is sealed in place with an inflation valve (8) inserted beforehand.

When completed the struts can be cut out and the vessel can be packaged (not shown) and transported to its destination before being inflated and rendered rigid by the addition of an epoxy or resin (9) which can be rolled onto the GRP or sprayed with a two part gun (not shown) and which can include further chopped strand glassfibre (not shown) to increase the rigidity of the vessel.

Once rendered rigid with one or more skins the vessel's deck (7) and struts (4) can be cut as required for a wheelhouse and partioning etc. (not shown) and in Fig. III are shown areas (10) (11) & (12) where the skin (1) is not epoxied in order to make it easier to cut out particular areas such as the ingress or operational area (10) and windows (11) & (12).

This latter method is particularly necessary where kevlar or kevlar combinations are used because of the difficulty in cutting that material. Fig. IV shows a method to create a typical catamaran profile whereas Fig. V shows a method of creating a box section in that the struts (4) are

joined to the inner skin (3) in the same manner but in Fig. 4 they are stretched across the corners to create the correct shape.

Fig. VI & VII show a typical inflated dome type house which can be rendered rigid by means of epoxy or resin on GRP outer skin (2) after inflating at valve (8).

The struts (4) as are shown in VI & VII are again in a different form to those struts (4) in Figs. II, IV & V and are designed to make the dome as symmetrical as possible.

A doorway (14) can be added to the dome before or after rending the rest of the structure rigid by means of a zip commonly called a 'Maxigrip' (15) and the doorway section (16) can be left, without epoxy and in fact could be of a different easy to cut material providing that it was capable of withstanding the same pressure as the rest of the dome and was compatible with the skin (1) from a sealing point of view.

The door itself (not shown) and doorway (14) can again be manufactured in the same way with a double skin, but need not necessarily be constructed in that way.

Once the dome was rigid the doorway section (16) can be cut out and the struts (4) can be cut out and removed.

Fig. VIII shows a monohull with a further skin added internally (on an outer rigid skin (1) composed of a pressure sensitive encapsulated epoxy (17) (as is given in more detail in Figs. XXXI-XXXVI) on a GRP or carbon or kevlar outer layer (18) and an inner layer of polyurethane (19) which in turn is sealed to struts (4) to create the correct shape.

When the second skin (17, 18 & 19) is in place the structure is inflated whereupon the encapsulated epoxy breaks squeezing through the GRP (18) to form another rigid skin.

Fig. IX shows a Magnus Effect Rotor composed of a double skinned inflated section (20) forming a tube within which are attachment points (21) to be attached to a rotating tube (not shown) which is also attached to a disc (not shown) by further attachments (22) in order to spin the rotor and create the bottom plate whilst reducing torque problems on the rotor. A sealing diaphragm (24) ensures that the top section (25) is a continuous inflated body with the double skinned section (20) and the same inflation valves (18) is used for both sections. The double skinned section (20) has struts (4) between each skin much as the inflated tent, warehouse or greenhouse in Fig. X, but they form a tube rather than a semi-circular structure as in Fig. X.

The diameter at (23) is wider than at (25) but the material, if flexible can with internal pressure take up the shape in Fig. IX because of the greater diameter at (23). The eventual shape at (26) will depend on the elasticity of the material and the pressure of inflation.

The original shape of the rotor before over inflation is shown at (27) and if the material used in manufacturing the rotor was not extensible such as nylon/polyurethane/kevlar it would have to be very carefully cut to form the balloon's shape as shown at (26).

The top disc (28) has internal struts which are extensible as are the struts in the double skinned section

(20) but in other cases it may be necessary not to have extensible struts in which case they would be a lamination of polurethane or some similar thermoplastic with nylon or kevlar or a combination of these or some other non extensible material. Once the rotar is inflated to its correct shape the outer surface can be rendered rigid by the addition of an epoxy resin if required. Parts of it can be rendered rigid for instance between (20) & (23) and between (29) & (25) as well as the top disc (28). This would leave an area between (23) and (29) which was not rigid and therefore if it was required that a bulbous section (27) should be created, further inflation could occur without distorting the other sections because they would have been rendered rigid by the cured epoxy.

A further alternative would be to inflate the complete rotor at (8) and only epoxy between (20) and (26) and for instance the top disc (28) in order that the rotor could be deflated to fit within the hardened section (20)-(26).

The top section (26)-(25) could be withdrawn into the lower section (23)-(26) by means of a line or cord (30) attached at point (31) on the top disc (28) which could be wound around a motor within the rotational machinery at the platform on deck (not shown).

The structure in fig. X could be used in various forms and sizes as a greenhouse, warehouse, temporary or permanent workshop, NBC building etc. depending on the materials used and the processes used to render the outside skin (32) and inside skin (33) rigid or non-rigid.

In the case of a greenhouse it would have to use GRP or some similar product which changed from opaque to virtually clear with the addition of a chemical or epoxy for the outside skin (32) and possibly the internal skin (33) would not be rendered rigid, whereas in other cases a variety of laminations could be used where the building or parts of the building need not be capable of letting in light.

However in some buildings parts of the building may be required to let in light and other parts would need to stop light from entering, so a variety of materials such as kevlar/carbon mixtures could be used on one part and GRP on other parts and both surfaces (32) and (33) could then be epoxied or rendered rigid by chemical reaction. The ends (34) could have a non rigid double skin or single skin with a zip (35) or they could be rendered rigid and a door inserted (not shown).

The ribs (4) can be placed in such a way that the curvature of the structure is performed in that the circumference of the inner skin (33) is shorter than the circumference of the outer skin (32) and the gap between each strut is greater on the outer skin (32) than the inner skin (33).

Fig. XI shows a technique whereby a chair (35) can be formed with struts (4) and external skins of kevlar or kevlar/carbon laminated to polyurethane which is then rendered rigid on the lower surface (37) and back surface (38) to form a base while the top surface (39) can resist vandalism and cigarette burns and at the same time still be

comfortable to the occupier by an automatic or manual method of inflation (not shown) through valves (8) in order to change internal pressure.

The pockets (40) holding the seat (35) to the base frame (41) can be rendered rigid or left supple as required depending on whether the chair (35) needs to be deflated and stacked one on top of another at any time (not shown) as may be advantageous in a military vehicle or commercial airline.

Fig. XII-XIV shows a container (42) which has ribs inserted into a preformed pocket (44) or which are affixed after the container has been inflated through valve (8) and rendered rigid by means of an epoxy, resin or glue. If required the ends of the ribs (45) (which could themselves be manufactured as an inflated tube with a GRP or kevlar laminate on polyurethane before being rendered rigid (not shown) can either be bolted or screwed together (46) as shown in Fig. XIII or a tensioned clasp (47) could be used as shown in Fig. XIV.

This latter method (47) could be useful in particular if the last panel to be affixed (48) had zips (49) used such as 'Maxigrips' to facilitate removal and loading of the container.

Figs. XV & XVI consist of a rudder (50) which has internal struts (51) sealed to a skin (52) composed of an internal thermoplastic material (53) and an external GRP (54). A tube (55) is inserted into the leading edge of the rudder at manufacture so that when the rudder is inflated through valve (8) and rendered rigid the pin (56) can be

inserted on replacing the broken rudder with the new rudder (50) in a vessel such as is shown in Fig. 1.

Figs. XVII, XVIII & XIX refer to a bridge (57) which is composed of 2 main longitudinal sections (58) & (59) between which are transverse joining sections (60) which stiffen and spread the sections (58) & (59) apart to the required distance to allow vehicles to pass over the bridge (57).

Fig. XVIII shows a cross section at H-H composed of ribs (61) forming a stepped track (62) into which a wheel will be guided whilst further ribs (63) form an arched section (60).

When the bridge has been unfolded it can either be one section or many sections which can be joined together (not shown) and it can either be floated across the river or laid across the marsh etc. before being hardened or more likely it will be hardened before being placed in position.

Figs. XX & XXI refer to the difference between a non rigid inflated aeroplane or space vehicle (64) and a rigid version (65).

In the non rigid version (64) it is probable that tubes (66) composed of thermoplastic material will be sealed horizontally in between the top and bottom skins (68) & (69) to take the aluminium tubes (70) & (71) for the engine cross tube (72) and rudder and elevator assembly cross tube (73). The same cross tube (72) is used to secure the down tubes (74) for the wheels (67) and a bracing tube (75) is then secured at (76) to the envelope and/or it may be secured

directly or indirectly to tube (70).

However as can be seen the resultant inflated aeroplane will be non rigid and will tend to bounce on the runway and will not be capable of high speed flight. It will also have a considerable weight penalty because of all the extra attachments, thermoplastic tubes, aluminium or carbon tubes etc. so in inflated aeroplane (65) the skin has been rendered rigid by the addition of epoxy to a kevlar/polyurethane laminate enabling the attachments such as wheels (67) engines (77) elevator (78) and rudder (79) to be either joined directly or bolted to inserts (80) which can be laminated at the time of manufacture or after inflation and hardening of the outer skin. Not only therefore will the vehicle be capable of being inflated to considerably higher pressures becoming more rigid, less likely to distort in the air and therefore capable of higher speeds, but it will also be capable of more nett lift from a lighter than air gas.

Figs. XXII-XXIV show two methods of strengthening a weld (81) on peel which is the weak point in any such method of manufacture.

The two pieces of material are heat sealed (81) or otherwise seamed on peel (84) in that if a pressure is introduced at the point (85) by inflating the body (86), the two pieces of material (82) & (83) are liable to peel away from each other. To reduce or eliminate the possibility of this happening one of the pieces of material (83) can be cut close to the weld at (81) and the other piece of material

(82) can be glued or epoxied to the outside of the fabric at (87). However as the inside of the material could be polyurethane or some similar thermoplastic it is likely that this would not be as permanent as is possible with the method shown in Fig. XXIV, whereby the two pieces of material (82) & (83) have to be cut close to the weld (81) and then a similar piece of material (88) as is used on the outside of the laminate (89) & (90) would be used to take the internal pressure by being epoxied or glued or otherwise affixed to the pieces of material (82) & (83) thereby relieving the peel pressure caused by inflation because instead of a peel joint it becomes a sheer joint which is more difficult to destroy.

Figs. XXV-XXVII refer to a sequential method of creating different shapes within by way of example a vessel with parallel sides.

In Fig. XXV the vessel is composed of an inner membrane (91) of polyurethane, latex or otherwise extensible thermoplastic material to which is laminated or otherwise placed a chopped strand fibreglass or otherwise movable layer of GRP etc. (92).

A valve (95) is sealed into the vessel and a layer of epoxy or other type of chemical is rolled or sprayed onto the surface after inflation in between (98-100) & (99-101) leaving a gap between (98-99) & (100-101) respectively which does not have epoxy. Further inflation is carried out after the epoxy hardens and because the distance between (98) & (99) is greater than the distance between (100) & (101) the vessel will expand at a greater rate at (102) than at (103)

as shown in Fig. XXVI whereupon those areas can be sealed with epoxy between the points (98) & (99) and (100) & (101) respectively.

However it is possible that the area between (98) and (99) may require further strengthening as could the area between (100) & (101) and therefore further piece(s) of material (104) & (105) compatible with the original outside material are epoxied to those areas as shown in Fig. XXVII.

It is possible that at this stage the vessel may be cut at points (106) & (107) to form a tube with that particular shape, but the same technique could for instance be used to create an aerodynamic or hydrodynamic shape even with parallel struts in between two membranes provided that the strut material in particular and, depending on the amount of extension required, the outside membranes as well were elastic, and provided that the epoxying was done in sequence with further inflation pressure to increase the diameter at the required points.

Figs. XXVIII & XXIX show how a radar reflector (108) can be stowed within a deflated sphere (109) composed of by way of example kevlar/polyurethane laminate which is extremely light but which on inflation through valve (8) expands out to a known accurate diameter.

The internal reflector (108) is attached to the outer sphere (109) by means of a primary tube or rod (110) at the points (111) & (112) and also at the points (113) (114) (115) & (116) so that when the sphere (109) is inflated it automatically pulls the octohedral as depicted in Fig. 29 or

tetrahedral (not shown) accurately into the correct shape even though there is no other rod or tube similar to (110) in the reflector (108).

However between the points (113) & (112) by way of example and between all other similar points a kevlar or wire tensioner is attached to both points and the silver nylon mesh.

The reflector itself (108) can be constructed of nylon mesh (94) coated with silver and protected against the environment by polyurethane such as is manufactured by Chemring and the central tube (110) could be extendable to reduce packaged size in a similar way to their 448 model, but the rest of the reflector (110) is dissimilar in that there are no other tubes or rods and the balloon creates the correct and more accurate shape of the octo- or tetrahedral particularly when epoxied to form a rigid sphere which renders the reflector (108) unaffected by wind and weather whereas in the 448 model not only does the wind distort the reflector, but the silver on the nylon mesh is affected badly by sea water and within 24 hours considerable loss in attenuation occurs. In Fig. XXX a reflector (108) within a sphere (109) is held within an aerodynamic balloon (117) or aeroplane or RPV by attachment to the balloon at (118) (119) (120) & (121) in order that it is aligned correctly for maximum distance of signal when the balloon is in its normal flying position.

Fig. XXXI through to XXXVI show how in general the material(s) are laminated and then rendered rigid and in

particular how this could be achieved by means of an encapsulated glue, epoxy or chemical.

Fig. XXXI shows a lamination of polyurethane (122) with chopped strand glassfibre (123) bonded by means of a laminating agent (124) and with an encapsulated epoxy (125) on the outside. At this stage the membrane is uninflated and relaxed.

Fig. XXXII shows that as the membrane is stretched by inflation the capsules release the resin (126) into the chopped strand glassfibre (123) and in Fig. XXXIII is shown a smooth inflated membrane where the chopped glassfibre (127) laminated by (124) to the polyurethane (122) has formed a single hardened shell or skin.

Fig. XXXIV shows how a second membrane consisting of thermoplastic membrane (128) laminated to kevlar (130) by means of adhesive (129) with an encapsulated or pressure sensitive adhesive (131) all in a relaxed (uninflated) form, lies beneath the first hardened skin or membrane (122) (124) & (127).

Fig. XXXV shows the position as the second membrane lies close to the first membrane and in particular the encapsulated or pressure sensitive or otherwise unactivated epoxy (131) has not yet touched the lower polyurethane membrane (122) of the first skin. At this stage particularly with an encapsulated glue or epoxy the internal inflated membrane can be moved around to obtain the correct position as required.

However in fig.XXXVI the encapsulated epoxy or glue

(131) has been broken by the pressure of the second skin being inflated against the first skin and on being released the epoxy or glue fixes the second skin against the polyurethane inner membrane (122) and at the same time hardens the kevlar (131) in the lower skin.

Alternative methods are to glue or epoxy outer skins or membranes to the first skin rather than inner skins or membranes.

Fig. XXXVII shows the preferred element of a heat seaming or sealing or welding system which enables single and two dimensional seams to be created to obtain a 3 dimensional product. In general a relatively simple aerodynamic balloon with a low lift to drag can be created by a single curved element on 2 seamable membranes such as polyurethane or polyurethane laminates or even polypropylene when the 2 membranes are laid face to face with each other on a flat table and this is particularly so when the membranes are elastic such as polyurethane rather than relatively inelastic such as polypropylene.

However if a more complicated curvature is required to create a more aerodynamic shape, struts and/or 2 dimensional seams are required, and therefore again the element shown(132) is ideal for this purpose.

It is a heating element composed of a two core mineral insulated (134) heating cable (133) which has a copper, cupronickel or inconel sheath (135) which has a further sheath (136) typically silicone over the first sheath (135) to even out any 'hot spots' which are sometimes created by

such an element.

In figs. XXXVIII & XXXIX the element (132) with sheath (136) is affixed to a backing plate or backing material (137) by means of a silicone adhesive (138) such as Loctite 384 which is both thermally conductive (again to even out 'hot spots') and electrically insulating.

The backing plate or material (137) should reflect heat rather than conduct it in order to protect the platten (139) and to reflect the heat generated by the element (132) back to the seaming area and typical materials could be Elephant Hide which is also used in high frequency welding or silvered glass or glassfibre. Around the outside of the Si. tube (136) and the silicone fixing adhesive (138) is a strip of PTFE tape (140) with a self adhesive glue on the inside which stops the element from sticking to the membranes to be heat sealed.

The backing plate (137) can be glued or bolted or screwed to the platten (139) which can be of any material capable of withstanding warping caused by extensive heat over the area required to seal the membranes.

The platten (139) can be brought down onto the table or base (141) which can be covered by a protective layer of aluminium or silver paper (142) which reflects heat back and a silicone cloth (143). Alternatively a sponge (not shown) can be laid between the table or base (141) and the silicone (143). Between the platten (139) and the base or table (141) are laid face to face the two membranes to be seamed (144) & (145) which can consist of different thermoplastic materials

provided they are compatible, but the top membrane (146) and the bottom membrane (147) do not need to be thermoplastic and can be any other material laminated to the thermoplastic materials (144) & (145) or indeed (144) & (145) may not be laminated to any other material, but each might just be a single membrane.

Fig. XL & XLI show a sealing system used with a DC battery (148) which has a base (149) hinged at (150) with a top plate (151).

The top plate (151) contains a platten with heating element (139) and the base (149) contains typically a silicone x section (141) rather than the system described in Figs. XXXVIII & XXXIX.

On the top plate are housed 2 handles (152) & (153) by which it can be held and a switch system (154) which operates a hydraulic or spring loaded or air operated ram (155) to press the platten (139) against the base (141) to seal the product (156).

Alternatively the operator (not shown) can push the base (141) and top plate (139) towards each other manually and in the region of the ram (155) a return spring or springs (not shown) will release the base (141) from the top plate (139).

The element maintains heat throughout the operation and as is shown in Fig. XLI the thermoplastic membranes (144) & (145) can be at any angle before being joined together.

After completing the seaming the container (156) is inflated by means of inflation valve (8) and the epoxy is

rolled or sprayed onto the container.

By this means it is possible to make a totally secure and environmental proof container which should be of particular use in shipping, but the same technique of seaming could be used by way of example for other purposes such as silage clamps without epoxying the membranes and in that particular case the air would be sucked out rather than inflated from valve (8) and the material used could be considerably cheaper and unlaminated such as Reedex F polypropylene.

Fig. XLII shows a plan view of a tyre (157) and wheel (158) being manufactured which consists of two laminated membranes of, by way of example, kevlar and polyurethane laid with the two thermoplastic materials in face to face contact with each other.

An element (159) is set in a platen (not shown) and curled in a circular fashion until point (160) where it exits from the heat sealing side of the platten but re-enters the heat sealing side of the platten at (161) whereupon it again is curled in a circular fashion to terminate at (162). To ensure a continuous seal the elements touch each other at (161) & (162) as they do at (159) & (160). Alternatively separate elements can be used for each circular seam (not shown).

Before the 2 membranes are laid one on the other a valve (163) and a tube (166) are inserted or sealed in a position so that the tube (166) can be used to insert a further tube or shaft with which the wheel is rotated or free

wheeled depending on whether it is the driven or freely rotating wheel.

Once the tube (166) and the valve (163) are in position the platten (not shown) is brought down onto the membranes which lie on a table (not shown) typically covered with aluminium, soft sponge and silicone cloth (not shown).

The platten can be brought down by hydraulic or pneumatic or mechanical rams (not shown) or can indeed be lowered manually for a period typically not more that 80 seconds typically 110-120 watts per metre of weld run typically at a pressure not exceeding 3½lbs per inch of weld run to seam the membranes together.

Having seamed the wheel and tyre in one 'pass' the platten (not shown) is raised and the tyre section (157) is inflated with a reasonably low pressure before adding the epoxy to harden the skin whereupon ribs (164) could be added by epoxying them onto the kevlar base.

Once completed the wheel (158) could be inflated at valve (165) before epoxying and a second or more layers of kevlar or glass fibres or other fibres could then be epoxied onto the first kevlar layer.

Because the loads per square inch are likely to be low in the combination tyre and wheel due to its size the peel strengths that are possible typically in the order of 120-140lbs per inch are sufficient to make this a comparatively low cost and efficient tyre, particularly in the largest sizes and in theory a tyre and wheel combination of virtually any size is possible. Where there is likely to

be an abrasive action of the tyre or whether the terrain is very rocky, the central tread or the sides could be strengthened with one or more layers of kevlar or carbon or carbon/-kevlar cloth before being epoxied and the seam joint (167) caused by seaming the two membranes together with element (159) can be covered with a strip of material such as kevlar and epoxied to transfer the seam from a peel joint (84) to a sheer joint (88) as shown in Fig. XXII and XXIV respectively.

The invention is not limited to the details of the foregoing and variations can be made thereto within the scope of the following claims.

However any feature disclosed herein, or any combination of features disclosed herein is an invention whether or not it is claimed separately in the following claims.

The invention also includes an inflatable flying machine which can be at least partially manufactured by the methods hereinbefore described. This flying machine is also an independent invention in its own right.

This portion of the present invention relates to a flying machine which can have the shape of a saucer.

There have been various attempts to construct inflated vehicles either as remotely piloted vehicles or as piloted vehicles, but in general whenever the shape was in the form of a flying saucer it has been unstable. A number of inflated vehicles are in the shape of a blimp or airship whereas others are spheres and still others are in the form of an

aircraft.

Most vehicles to date do not spin, but recently some spherical and airship or blimp shapes have been spun to create lift and/or forward movement.

However, the spherical and airship or blimp types have been spun on a horizontal axis and in general the lift is mostly created by the lighter than air gas such as helium with which it is filled or by angling the propulsion force i.e. engines to vector the thrust.

In the case of remote-piloted vehicles the system used to date has mostly been by means of helicopter type blades even if the shape was in the form of a twin sphere which was not rotated.

The invention provides a flying machine having two separate inflated sections rotatable in opposite directions around a central axis in order to create a stable platform.

This machine provides a comparatively inexpensible method for lifting considerable weights and towing large sea borne objects as well as being able to move at higher speeds than previously possible with an airship type of shape.

The machine also has a simple and effective method of gaining extra lift as well as downward thrust without having to vector the engine thrust itself.

The machine also can have a means of propulsion and lift or negative lift without necessarily having a engine and propellor system at all.

Preferably the means of propulsion can be by way of a direct current (D.C.) torque motor which is powered by on

board batteries. Said means of propulsion eliminates a considerable amount of weight at the outer extremities of the inflated envelope. Preferably the means of obtaining positive lift other than the lighter than air gas in the envelope as well as negative lift is by way of 2 or more winglets on the outer extremities of each inflated envelope which can either change the angle of attack of the winglets themselves or change the angle of attack of control surfaces on the winglets. Preferably the directional control is by way of rudders situated at the outer extremity of each winglet.

Said rudders can either by angled themselves or they can have control surfaces which are angled to obtain thrust in a particular direction. Preferably said rudders change their angle of attack as they revolve through 60° by means of servos controlled by an on board computer which has an arbitary zero according to a compass or some other bearing.

There can be provided a fail safe means of recovery should the rotation of the twin envelopes (saucers) be arrested because of mechanical or electrical breakdown or the envelopes themselves become deflated for any reason or the control surfaces of the winglets and rudders cease to function.

Said recovery system can be by means of a remotely deployed parachute that can be controlled from the on board computer or by means of an automatic release system should any disaster occur.

There can be provided one or more motors with propellers or jet engines or combinations thereof on each

winglet to provide forward thrust rather than a D.C. torque motor.

The counter rotating saucer may be a method of providing an aerial vehicle for electrostatic crop sprayers due not only to the slow speeds achievable, but also because of the minimum turbulence caused by the rotating saucers.

The inflated envelopes provide an extremely small radar cross-section and this, together with the fact that very small motors are needed to revolve the envelopes with little I.R. signal makes this an ideal RPV for military use and that factor together with its small size when deflated and packed and its flotation qualities make it particularly ideal for use at sea whether in a military, commercial or rescue situation.

This invention can also incorporate separate ballonets within each inflated section to control internal pressure with altitude, although this may not be necessary where the inflated sections are constructed of an extensible material.

The specific embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. A is a vertical view of the inflated flying saucer showing the two inflated envelopes together with winglets, motors and base frame.

Fig. B is a vertical view of a spherical capsule within which is housed the remotely deployed parachute.

Fig. C is a perspective view of the winglet, rudder control and engine with propeller propulsive system.

Fig. D is a view from above the top inflated envelope showing the way in which a particular direction is achieved.

Fig. E is a diagramatic view of the method of achieving other directions of travel.

Fig. A shows 2 inflated envelopes (a) & (b) with a base (c) which is schematically drawn as a housing for surveillance equipment (d). However (d) can equally be other electronic warfare equipment or for that matter base(c) could carry crop spraying equipment (not shown) on a long boom.

Base (c) could also be in the form of a flotation disc or floats for deployment and recovery at sea and it could equally be a capsule for man or cargo carrying purposes.

The inflated envelopes (a) & (b) are made from an impervious material by way of example such as nylon laminated to polyurethane or polyurethane/saran or in smaller versions could be an elastic material such as polyurethane or polyurethane/saran itself.

The envelopes (a) & (b) have a tube of material (e) welded, glued or heat sealed into them to enable metal or carbon fibreglass tubes (f) & (g) to be inserted vertically within them.

A fixed tube or shaft (h) is inserted within the tubes (f) & (g) and bearings (1) (2) (3) & (4) are housed between the fixed tube or shaft (h) and the outer revolving tubes (f) & (g).

Thrust bearings (5) & (6) with retainers (9) & (10) encapsulates the tube (f) whilst allowing free rotation.

Thrust (7) & (8) with retainers (11) & (12)

encapsulates tube (g) whilst allowing it to rotate freely. Envelope (a) is retained in position by metal or carbon fibreglass plates (13) & (14) which are housed within pockets (15) & (16) respectively which are in turn welded, glued or heat sealed to the envelope(a).

Envelope (b) is retained in position by plates (17) & (18) which are housed within pockets (19) & (20) respectively which are welded, glued or heat sealed to the envelope (b).

The plates (13) (14) (17) & (18) can have a lip which has grub screw or other fixing methods to tube (f) & (g), but the act of inflation also ensures that envelopes (a) & (b) do not rotate around tubes (f) & (g) respectively.

To obtain the correct shape of envelope e.g. in the form of a flying saucer struts or ribs (i) are welded, glued or heat sealed into place and it has been found that a minimum of 8 ribs are necessary for this particular shape.

On the outer periphery of the envelope (a) are two winglets (j) & (r) which are held in position by means of moulded plastic or carbon fibreglass or metal plates (21) & (22) respectively together with frames (23) & (24) respectively which are housed within pockets (25) & (26) respectively welded, glued or heat sealed to envelope (a).

The same method is used to fix winglets (l) & (m) to envelope (b). However, an alternative method (not shown) is to insert an aluminium or GRP carbon fibreglass tube from one extremity to the other (within a cloth or plastic tube welded glued or heat sealed within envelopes (a) & (b) which has a bend in the centre to allow it to pass the tubes (f) & (g)

respectively. The winglets (j) (k) (l) & (m) would then be fixed to the transverse tube (not shown). Each winglet (j) (k) (l) & (m) has an elevator (n) which is controlled by a servo (o) from a receiver and battery pack (p) which can be controlled from an on board or base controlled computer (not shown).

In general all winglets (n) would be set at the same angle at any one time to obtain the correct angle of attack to ascend or descend or in order to keep in level flight.

In the example shown in Figs. A, C, & D each winglet has an engine with propeller (q) (r) (s) & (t) but in figures I & III the top envelope (a) is rotating counter clockwise and the bottom envelope (b) is rotating clockwise whereas in Fig. D the top envelope rotates clockwise as long as the other envelope rotates counter clockwise and that is the purpose of the opposing diagrams.

The engines (q) (r) (s) & (t) can be fueled from a header tank (27) which in turn are fed (58) from main tanks (45) & (46) by gravity if on top of envelopes (a) & (b) or if below envelopes (a) & (b) (not shown) by means of a pump (not shown). Again control of rpm can be achieved by means of a servo and receiver commanded from a radio transmitter by remote control either from a computer or by hand (not shown).

Engines (q) & (r) can rotate envelope (a) at a different speed than the rotation achieved by envelope (b) from engines (s) & (t) if necessary to achieve zero rotation of the shaft or tube (h).

An alternative form of thrust can be obtained by

rotating envelopes (a) & (b) by means of D.C. torque motors (u) & (v) which decreases the weight at the winglets and therefore is less likely to distort the envelopes (a) & (b).

On top of the winglets (j) (k) (l) & (m) respectively are aerofoils (28) & (29) (30) & (31) which have rudders (32) (33) (34) (35) attached which are operated by a servo (44) from signals transmitted through receiver (p). The rudders (32) (33) (34) (35) control the direction in which the vehicle travels and are in turn controlled from an onboard computer which angles them to achieve the direction in relation to an arbitary zero which could by way of example be a compass bearing of zero. In Figs. IV & V the method of directional control is given in more detail in that to travel North the winglets on envelope (a) which is rotating clockwise are in a position of North and South, and the North winglet's rudder (32) is angled towards envelope (a) whereas South winglet's rudder (33) is angled away from envelope (a). In envelope (b) the rudders (34) & (35) are in a neutral position and therefore they do not affect the direction of travel, so the higher wind velocity over the outer surface (as seen in diagram D of (32) and the inner surface of (33) will induce the vehicle to travel North.

There may be a slight variation to the direction due to the Magnus Effect being created by rotating the envelopes, although this should be minimal due to each envelope rotating in the opposite direction but once that effect is known for different rotational speeds it can be compensated for by angling the rudders differently or by changing the speed of

rotation of one envelope in relation to the other. In Fig. V three variations of direction are given schematically with, for the purpose of clarity, envelope (b) being shown inside envelope(a) although in fact they are of the same size.

Again schematically all rudders are shown in each drawing in the same position relative to each other and by way of example rudder (32) is in a similar position on envelope (a) as rudder (34) on envelope (b) whereas rudder (33) on envelope (a) is in a similar position as rudder (35) on envelope (b).

However as can be seen the rudders (32) & (34) are the drive rudders which compensate each other by rotating the envelopes in the opposite direction. The opposite rudders (33) & (35) give a small amount of drive in that direction, but as can be seen in Fig. IV when the winglets (s) & (t) are in the neutral position i.e. at 90° to the drive force, the rudders (34) & (35) are parallel to the direction of travel.

Similarly in Fig. E when each envelope (a) & (b) has revolved a further 90° the rudders (32) (33) (34) (35) would be in a neutral position i.e. parallel to the direction of travel.

In Fig. B is shown a failsafe method of recovering the vehicle should any disaster occur such as puncturing of the envelope or failure of the directional or height controls.

The capsule (d) is moulded from GRP or carbon fibreglass or spun from aluminium in 2 parts (36) & (37). The lower half (37) is moulded to include a collar (38) which is screwed or affixed by some other means onto the shaft or

inner tube (h) and the top half (36) is affixed to the bottom half (37) by means of pins (39) & (40) which can be withdrawn by means of a mechanical or pyrotechnic device (not shown). Within the capsule is a parachute (41) which is attached by means of its flying lines (43) to an eyebolt (42) which is firmly affixed to the tube (h). Once the pins (40) (41) are withdrawn either by a mechanical device such as a wire or line (49) lead up through tube (h) from the man carrying capsule (c) to the outside of the safety capsule (d) and then to the pins (39) (40) which would be angled downwards slightly or they could be withdrawn by a radio signal to a servo (not shown).

An alternative method would be by an automatic signal passed from the on board computer when disaster overtakes the flying saucer whereby the top half of the capsule (36) is released and the parachute (41) will automatically deploy, thereby reducing the descent speed considerably.

In this way the personnel or cargo can be safely recovered, and provided the passenger or cargo capsule (c) itself is capable of safe submersion in the sea, this can be a method employed over water as well as land.

All radio receivers and batteries as well as any microchips such as the directional control, speed control, elevator and rudder controls (47) (48) can be housed on top of the main petrol tanks (45) & (46) if the latter are used, and if not they can be housed within a water tight case in the same position. However, in general it would be advantageous to ensure that (45) & (46) were below rather

than above the envelopes (a) & (b) in order to ensure a lower centre of gravity.

If ballonets are required for higher altitude versions (particularly in the case where the envelopes (a) & (b) are not constructed of extensible material), these can be incorporated as shown in Fig. I where envelope (a) has a ballonet (50) shown in its extended form which is pressurised by a pump (56) with an inflation/deflation tube (53) leading to a valve 52.

In envelope (b) the ballonet (51) is shown in its extended position after being deflated by pump (57) which has an inflation/deflation tube (55) leading to valve (54).

The pressure regulation (not shown) can be automatic with an altimeter or controlled from a microprocessor according to altitude and inflation pressure of the ballonets (50) & (51) on take off.

Vent valves (59) can if necessary be incorporated in envelopes (a) & (b) respectively for emergency deflation.

Claims

1. A method of constructing an article comprising : providing an inflatable envelope of which at least a part is of flexible sheet material, and to at least a portion of whose outer surface is secured a layer of expansible reinforcement material; inflating the envelope; applying a settable material to said portion of said outer surface in a fluent state; and allowing said settable material to harden about said reinforcement material.

2. A method as claimed in claim 1, wherein said layer of reinforcement material extends over substantially all of the exterior surface of the envelope.

3. A method as claimed in claim 1 or 2, wherein a part of said envelope consists of rigid inextensible material or structure.

4. A method as claimed in claim 1, 2 or 3, wherein the expansible reinforcement material includes fibrous material such as glass fibres, carbon fibres, or textile fibres such as nylon, cotton, Kevlar (or combinations of some or any of those listed fibres with themselves or other fibres.

5. A method as claimed in any preceding claim wherein the settable material is a synthetic plastics material.

6. A method as claimed in any of claims 1 to 4, wherein the settable material is a cementitious material.

7. A method as claimed in claim 4 wherein the fibrous reinforcement is formed into a woven or non-woven layer as an extensible fabric, mat or batt.

8. A method as claimed in claim 7 wherein the fibrous reinforcement includes extensible fibres which serve principally to locate and hold the reinforcement fibres in an expansible layer.

9. A method as claimed in claim 8 wherein the extensible fibres are co-woven with the reinforcing fibres or formed into a batt with them.

10. A method as claimed in any one of claims 1 to 5 wherein the settable material is a rigid foamed plastics material.

11. A method as claimed in any preceding claim including the additional step of adding to the internal surface of the article, after said settable material has set, a further layer by expanding within the article or within a region of the article an expansible second envelope to urge a further layer including a settable material into intimate contact with formed walling of the article to unite therewith.

12. A method as claimed in claim 11, wherein the second envelope is removed after the second layer has set.

13. A method as claimed in claim 11, wherein the second envelope is secured to the structure by the second layer of settable material.

14. A method as claimed in any preceding claim, wherein after said settable material has set, one or more openings are cut into the article.

15. A method as claimed in claim 14 wherein the openings are cut in hardened areas of the article.

15. A method as claimed in claim 14, wherein the openings are cut in areas left coated with hardenable material for this reason.

17. A method of making an article substantially as hereinbefore described with reference to the accompanying drawings.

18. A boat hull made by a method as claimed in any preceding claim.

19. A catamaran made by a method as claimed in any preceding claim.

20. A building such as a tent or marquee made by a method as claimed in any preceding claim.

21. A road or bridge made by a method as claimed in any preceding claim.

22. A lighter-than air craft made by a method as claimed in any preceding claim.

23. A tyre and wheel assembly made by a method as claimed in any preceding claim.

24. A flying machine including an axis, a pair of inflated bodies mounted for rotation about said axis in opposite directions, and means for driving said bodies in opposite directions.

25. A flying machine as claimed in claim 1, wherein the axis extends generally vertically.

26. A flying machine as claimed in claim 1 or 2, wherein the bodies are annular and decrease in axial thickness from the axis to their peripheries.

27. A machine as claimed in any preceding claim wherein a shaft is coincident with said axis and each body is mounted by bearings for rotation about the shaft.

28. A machine as claimed in any of claims 24 to 27 wherein said means for driving said bodies in opposite directions includes a motor or engine.

29. A machine as claimed in claim 1 wherein each body has on its periphery a number of rudders whose disposition can be altered to control the direction of travel of the machine.

30. A machine as claimed in claim 29, wherein each rotor has a plurality of ailerons for controlling rise and fall of the machine.

31. A flying machine as claimed in any one of claims 24 to 30 wherein the bodies are inflated with a lighter than air gas to render the machine as a whole of positive or neutral buoyancy in air.

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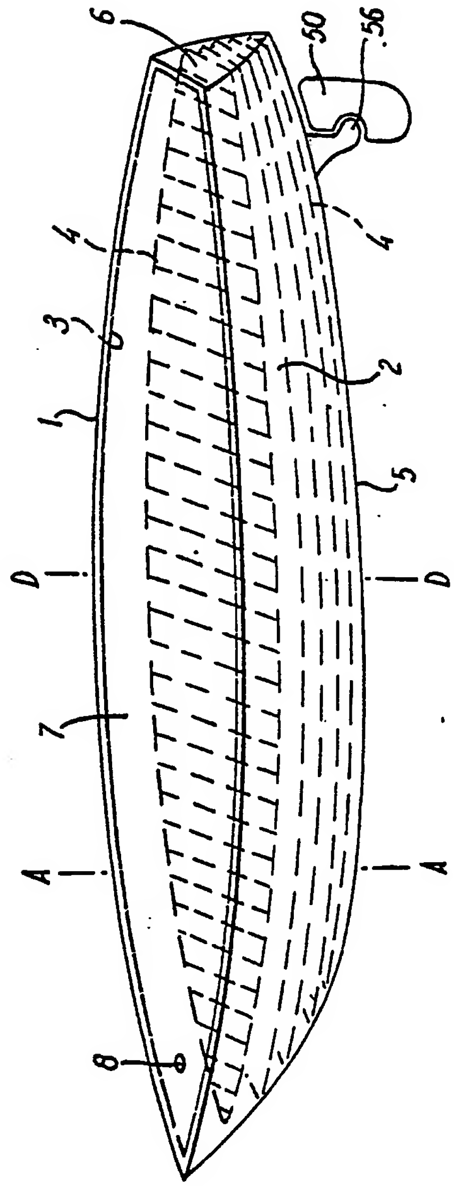


FIG. I

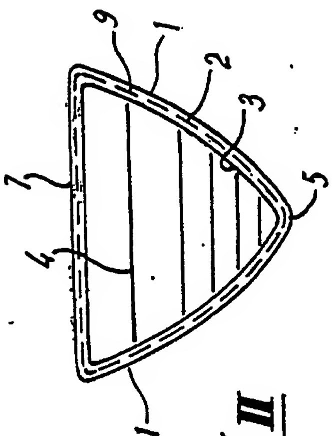


FIG. II

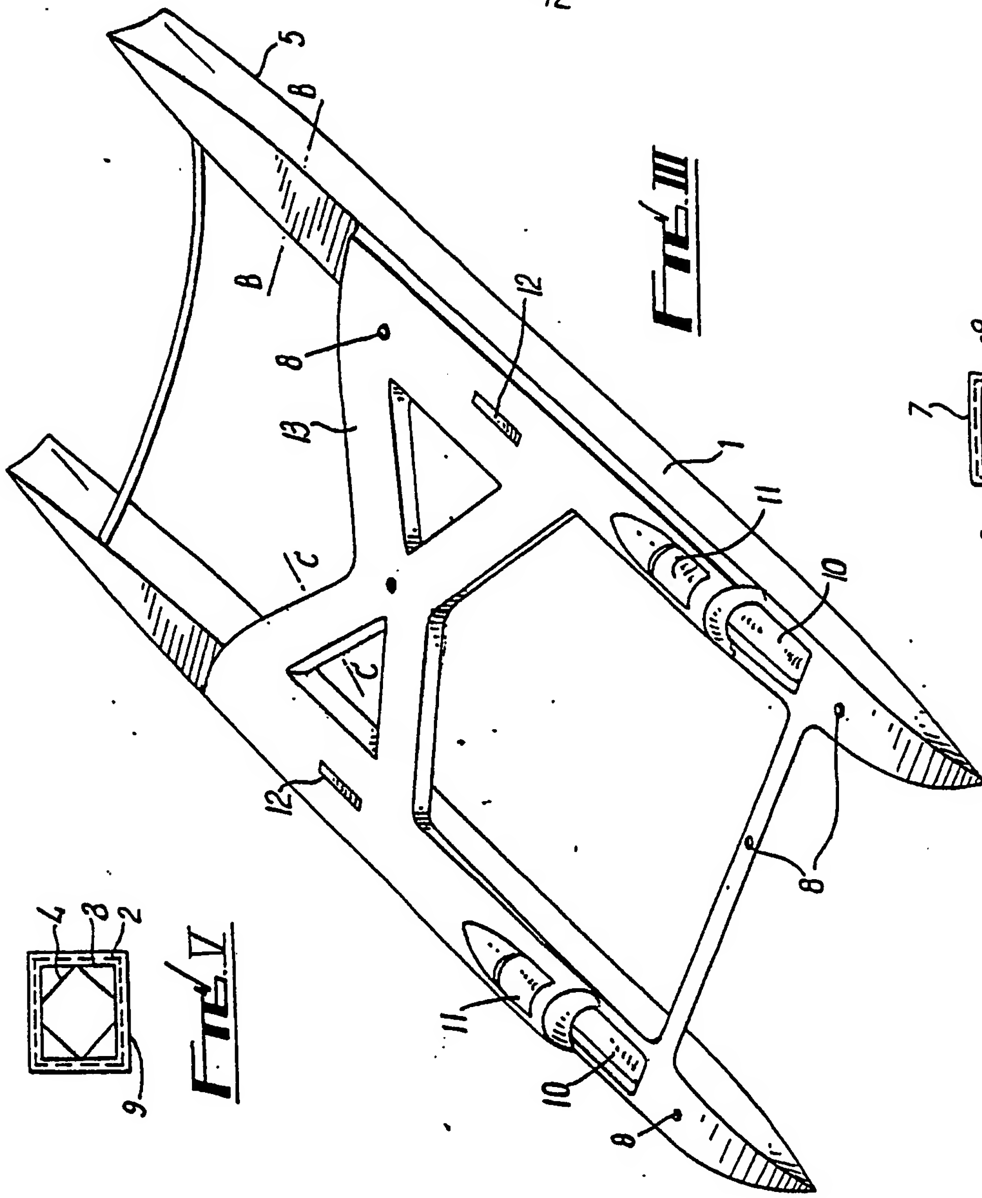


Fig. III

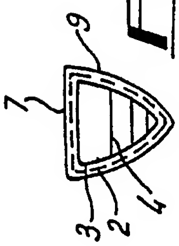


Fig. IV

Fig. V

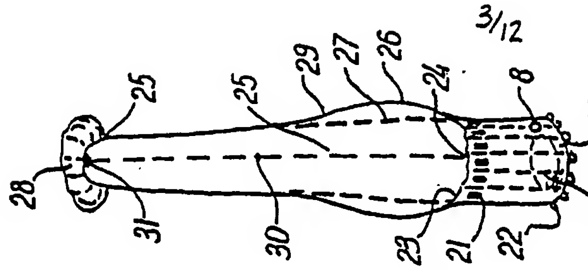


FIG. IX

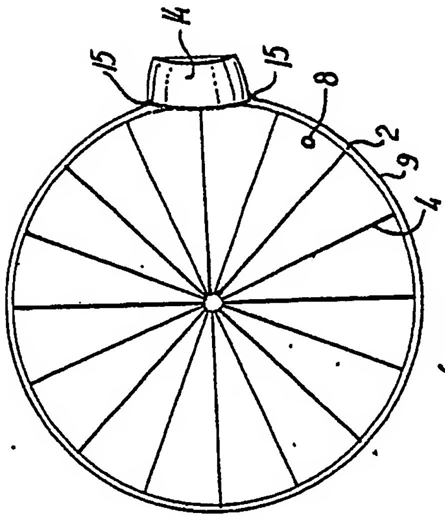


FIG. VII

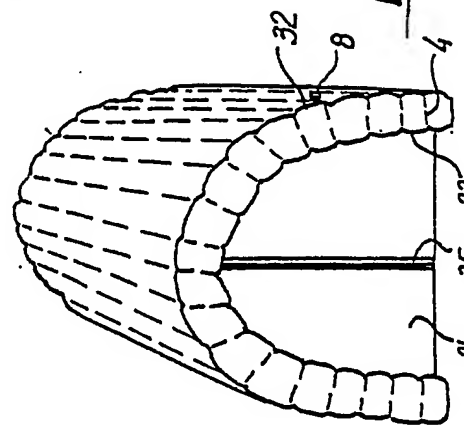


FIG. X

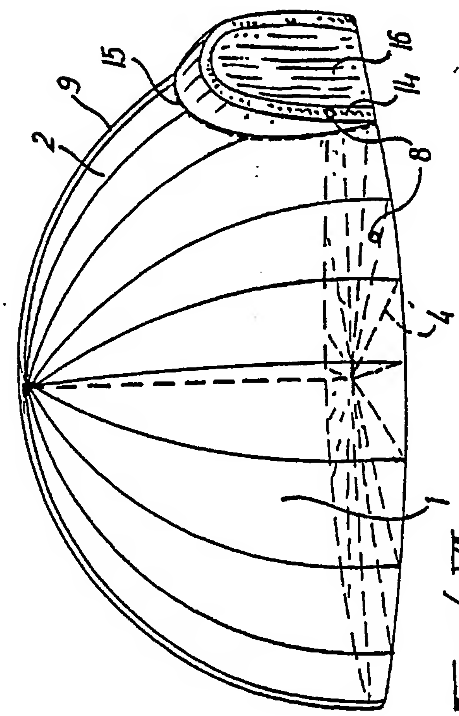


FIG. VI

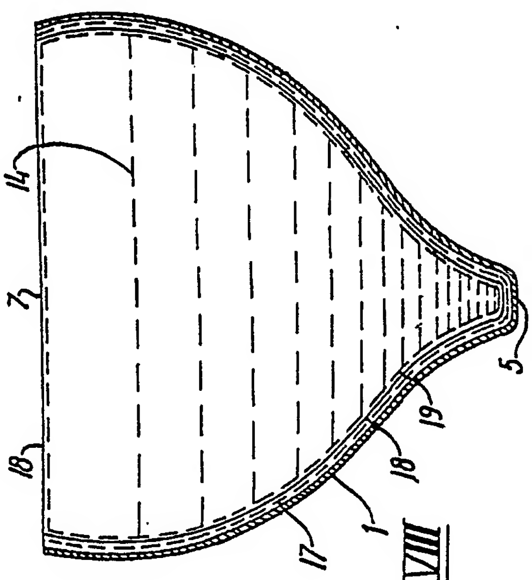
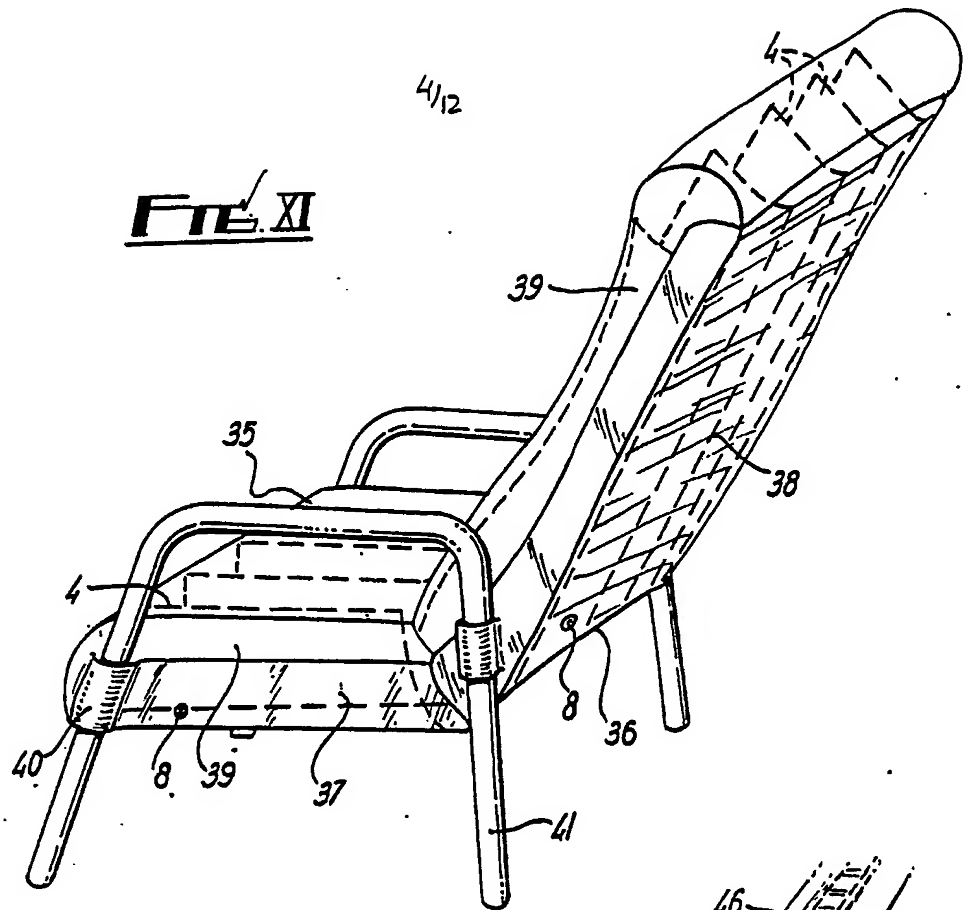


FIG. VIII

FIG. XI



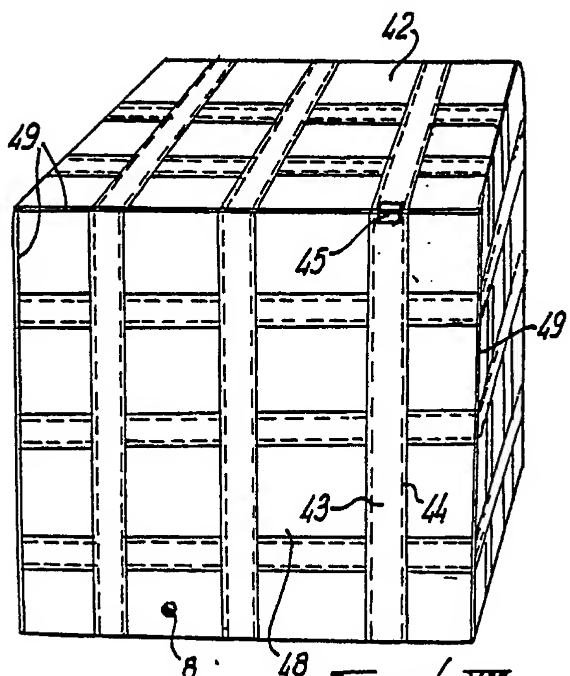


FIG. XII

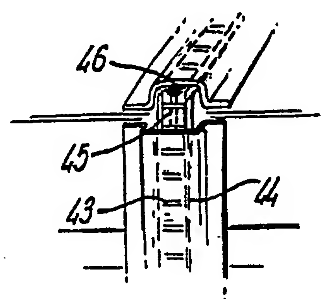


FIG. XIII

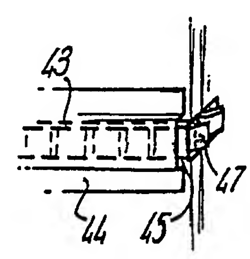


FIG. XIV

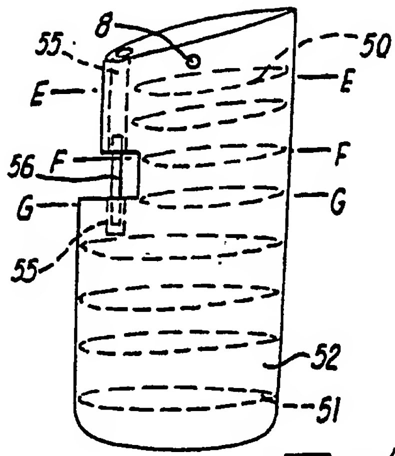


FIG. XV

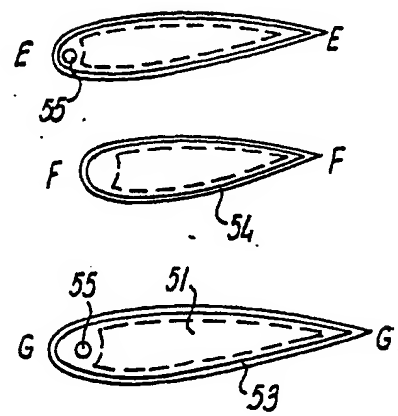


FIG. XVI

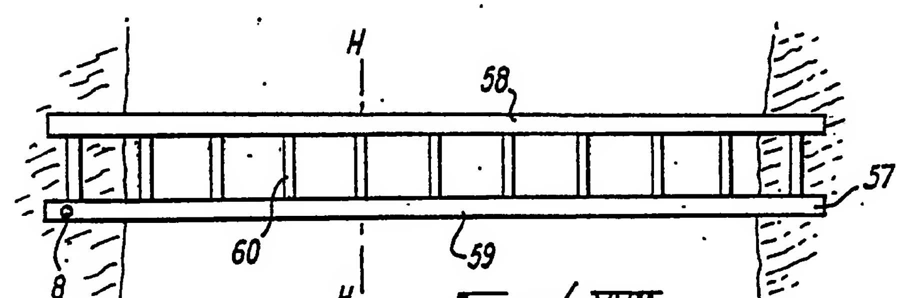


FIG. XVII

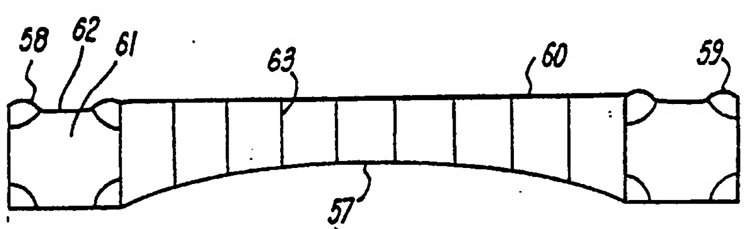


FIG. XVIII

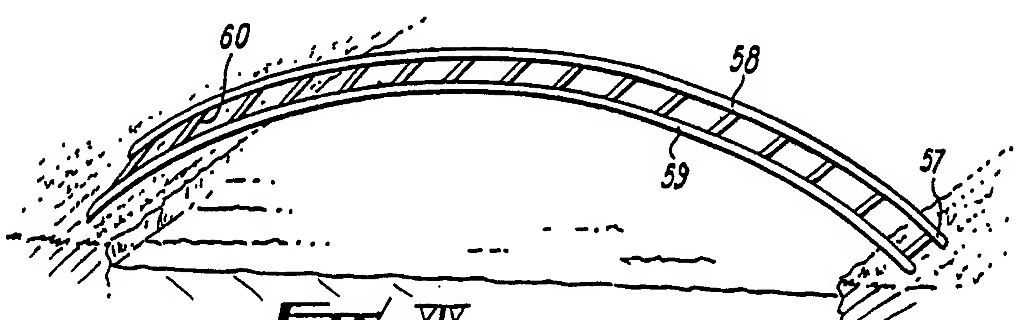


FIG. XIX

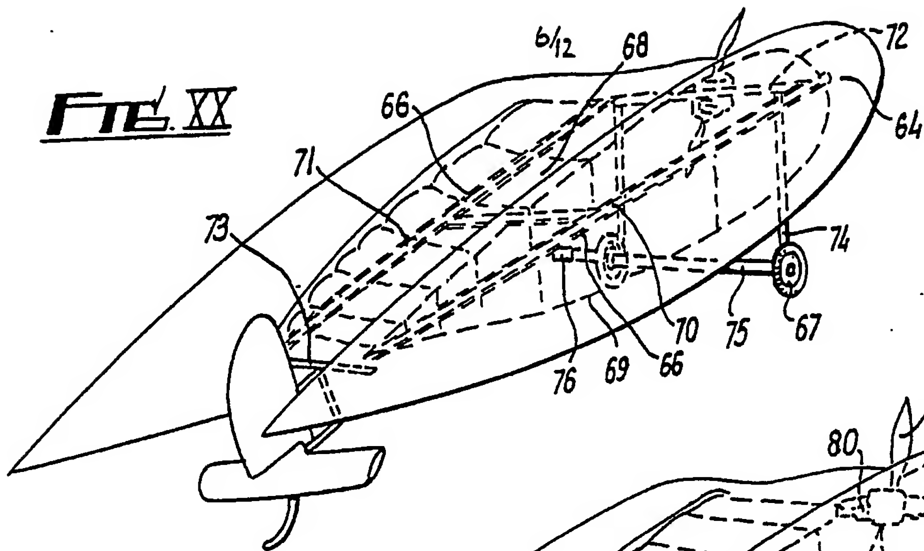


FIG. XX

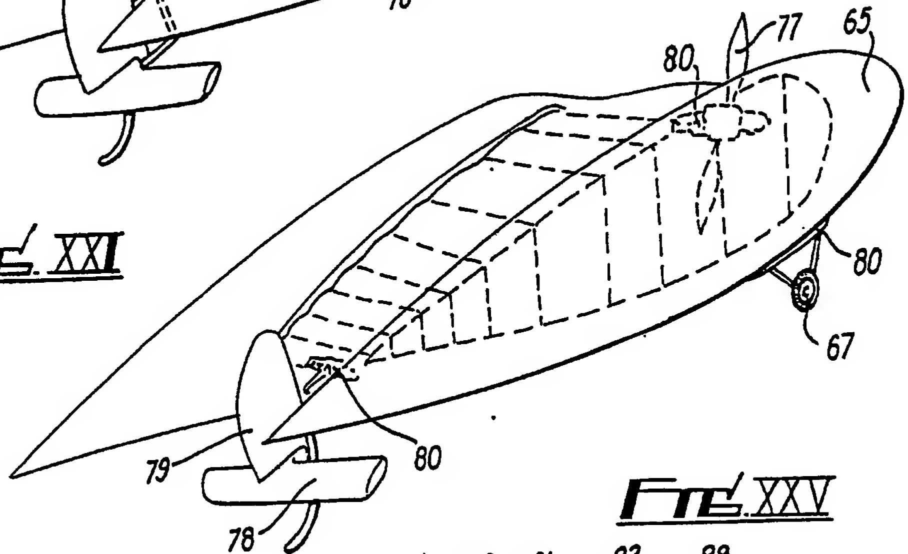


FIG. XXI

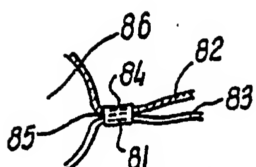


FIG. XXII

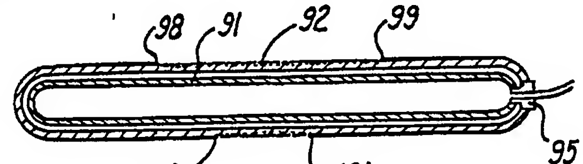


FIG. XXV

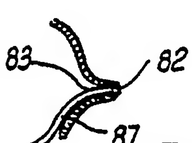


FIG. XXIII

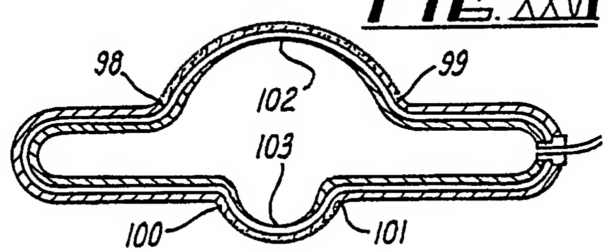


FIG. XXVI

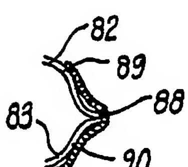


FIG. XXIV

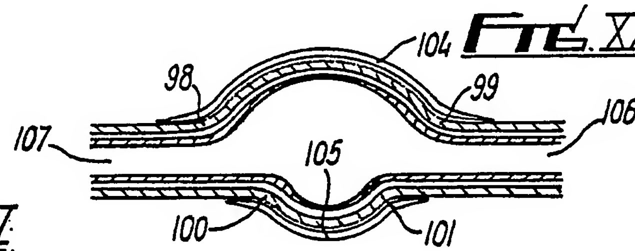


FIG. XXVII

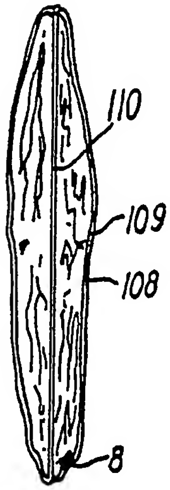


FIG. XXVIII

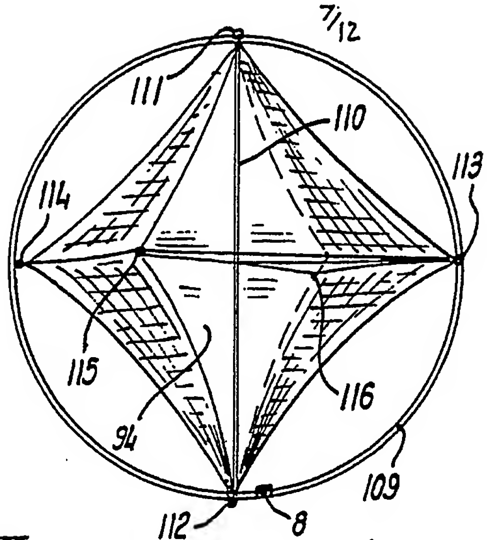


FIG. XXIX

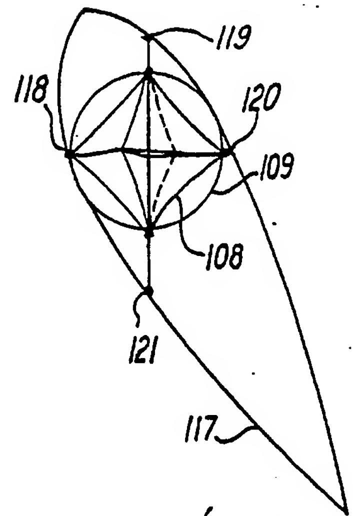


FIG. XXX

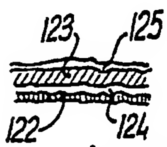


FIG. XXXI

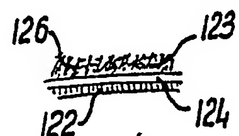


FIG. XXXII

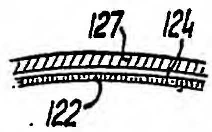


FIG. XXXIII

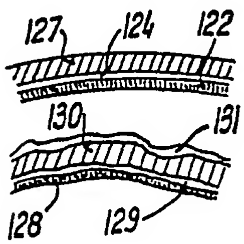


FIG. XXXIV

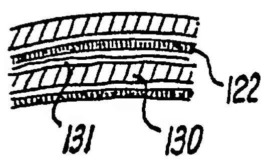


FIG. XXXV

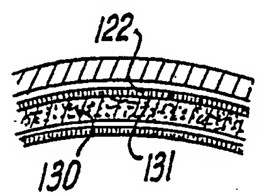


FIG. XXXVI

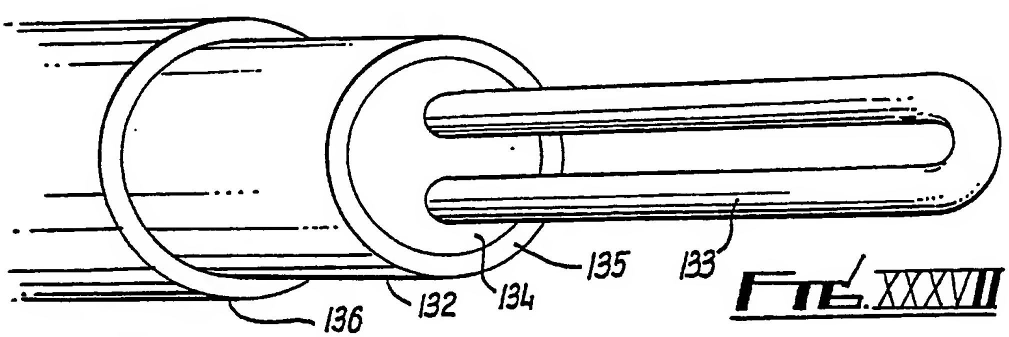


FIG. XXXVII

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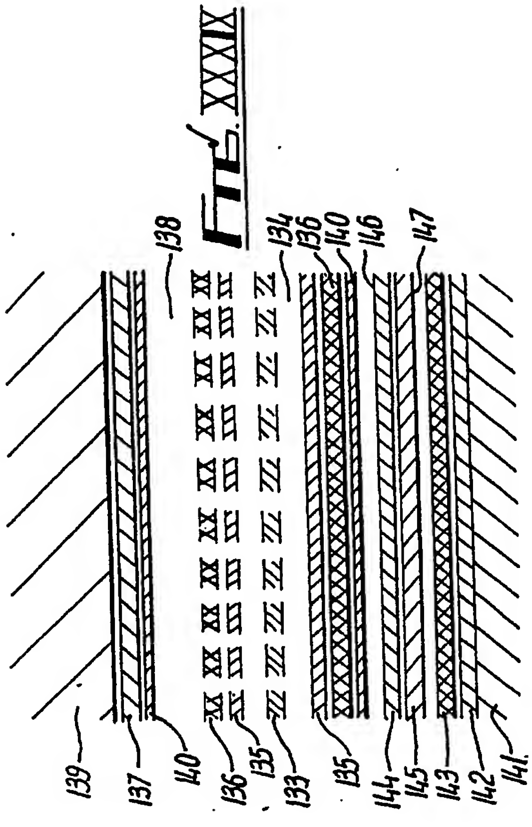

FIG. XXXIX

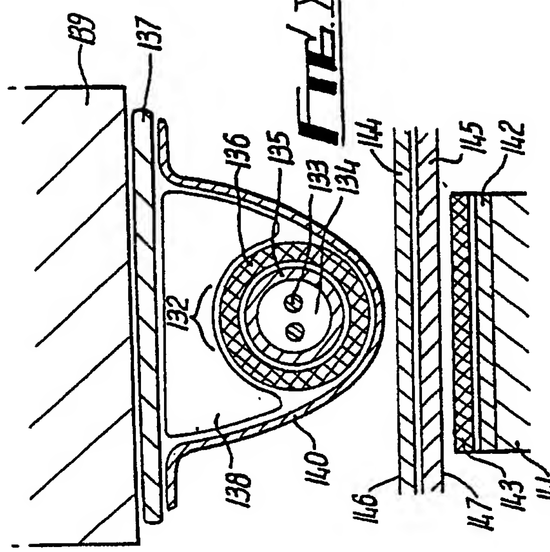

FIG. XXXVIII

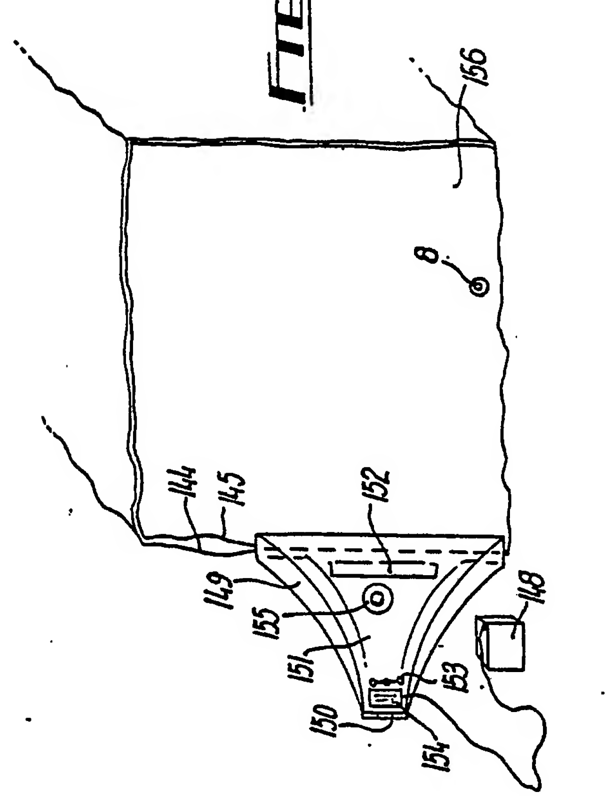

FIG. XLI

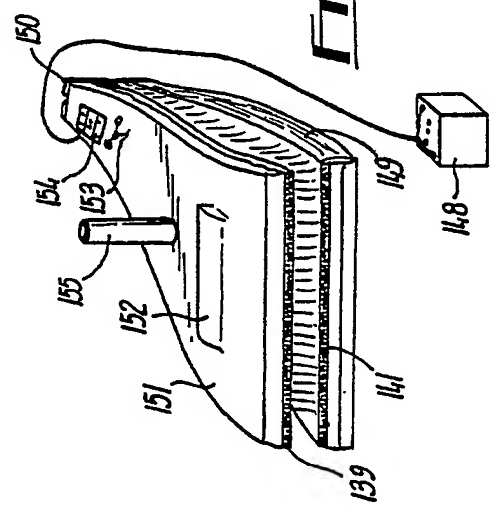

FIG. XL

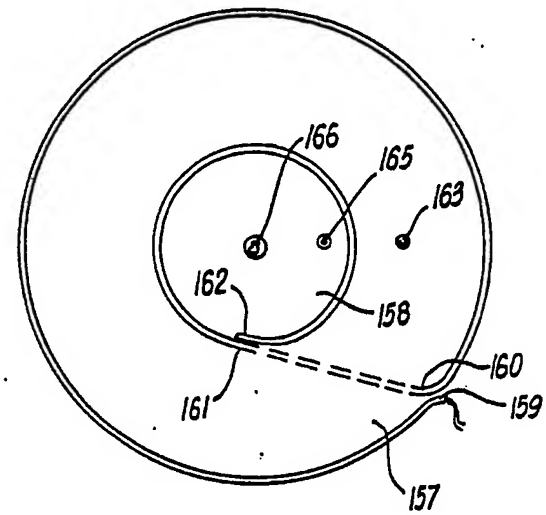

FIG. XLII

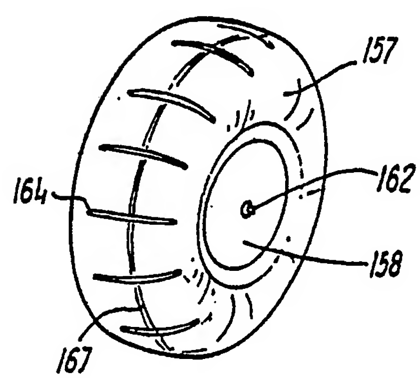

FIG. XLIII

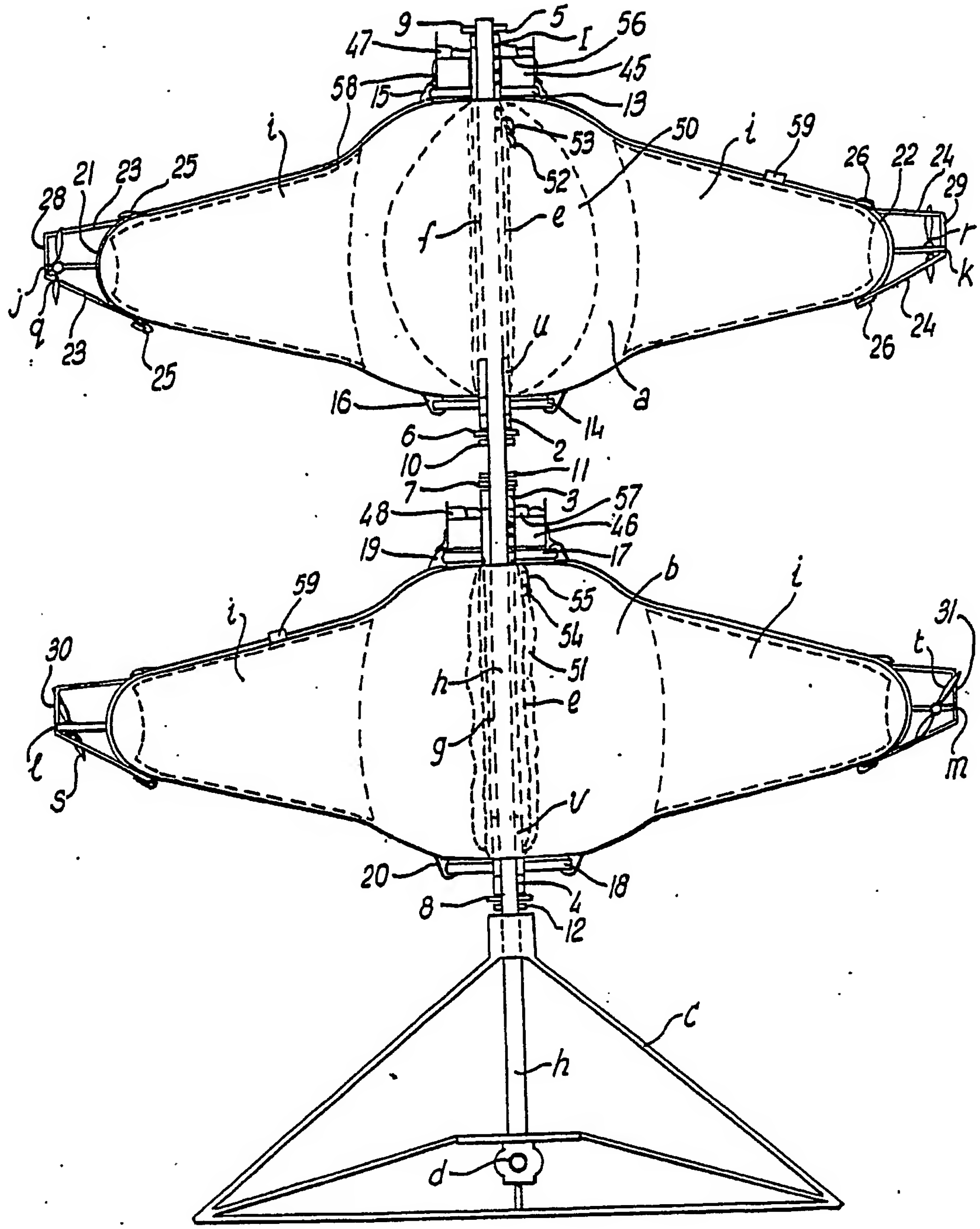
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FIG. A

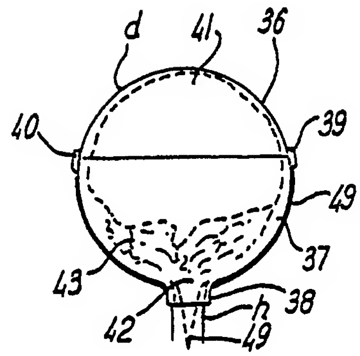

FIG. B

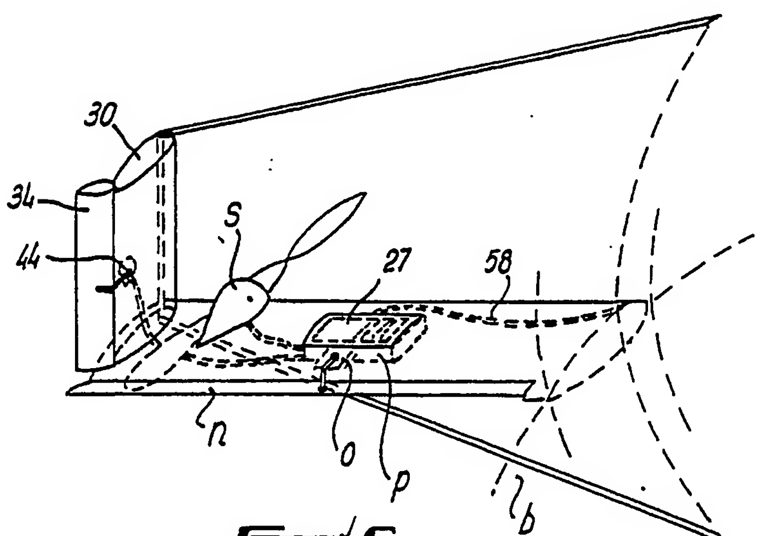

FIG. C

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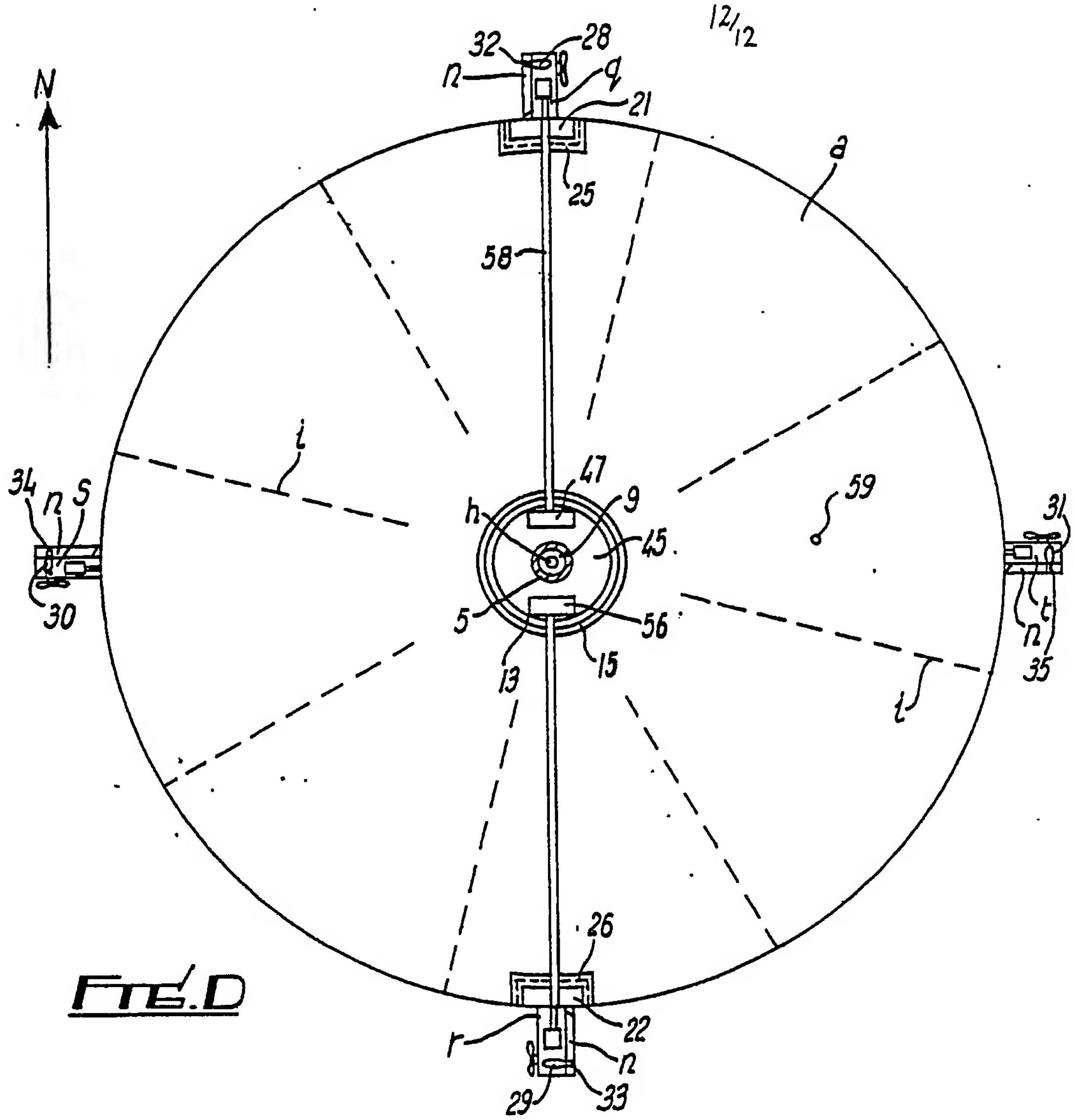
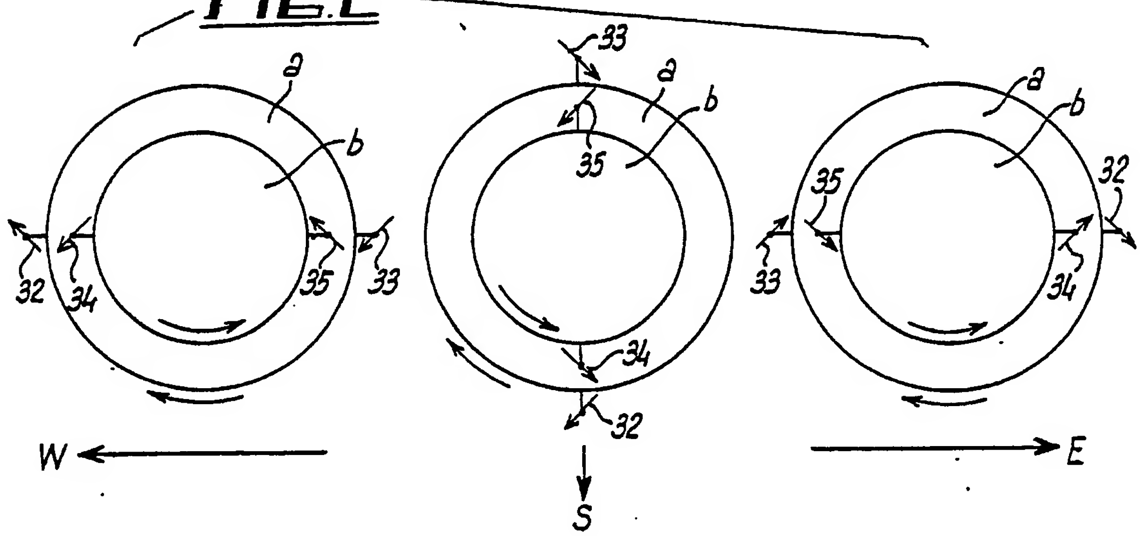


FIG.D

FIG.E



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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 86/00757

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: B 29 C 67/14; B 29 C 33/50; B 63 B 5/24; B 29 D 30/02
B 64 B 1/40

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	B 29 C; B 29 D; B 63 B; C 03 C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	FR, A, 1513175 (HANS FELLMANN KG) 2 January 1968 see the whole document	1,2,4,5,17, 18
Y		6,10
A		7,11
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X	FR, A, 1462775 (A. ZIEMANN GmbH) 7 November 1966 see the whole document	1,2,5,14-17
A		3,11
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X	DE, A, 1704266 (PÜTZER KUNSTSTOFFTECHNIK GmbH) 19 May 1971 see the whole document	1-5,17
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X	US, A, 3654050 (A.F. FRASER) 4 April 1972 see the whole document	1,2,5,10,17, 20-22
A		4
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Y	DE, A, 3417076 (A. TABAKOFF) 7 February 1985 see the whole document	6,10

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
19th March 1987	- 4 JUN 1987
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. VAN MOL

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	GB, A, 2061177 (MacAUSTER ELLIOTT & PARTNERS LTD) 13 May 1981 see the whole document	1,2,4-9,17-19,21
A	US, A, 4105817 (E.O. DUNAHOO) 8 August 1978 see the whole document	1,2,5,11-13,17,22
A	EP, A, 0114361 (HOECHST AG) 1 August 1984 see the whole document	1,2,4,5,7-9,17

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V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers .... because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers .... because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers .... because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

Claims 1-23: Method of constructing articles
Claims 24-31: Flying machine

(See PCT Form ISA 206 dated 26th March 1987)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers: 1-23

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SEC ND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	BE, A, 779290 (T. GEDDE) 30 May 1972 see the whole document	1,2,4,5,7-9,17
A	DE, A, 3022255 (A. MASSIMILIANO) 24 December 1981 see the whole document	1,4,7-9
A	FR, A, 2313195 (L.O.F. PLASTICS INC.) 31 December 1976 see figures 1-8	1,17-19
A	US, A, 3730244 (W.C. ROSS) 1 May 1973 see the whole document	1,17,23
A	FR, A, 2144809 (THE FIRESTONE TIRE & RUBBER CO.) 16 February 1973 see the whole document	1,17,23

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 86/00757 (SA 15507)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/05/87

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
FR-A- 1513175		None		
FR-A- 1462775		None		
DE-A- 1704266	19/05/71	None		
US-A- 3654050	04/04/72	None		
DE-A- 3417076	07/02/85	None		
GB-A- 2061177	13/05/81	None		
US-A- 4105817	08/08/78	US-A-	3962506	08/06/76
EP-A- 0114361	01/08/84	JP-A-	59120421	12/07/84
		DE-A-	3247617	05/07/84
BE-A- 779290	30/05/72	SE-B-	356710	04/06/73
DE-A- 3022255	24/12/81	None		
FR-A- 2313195	31/12/76	None		
US-A- 3730244	01/05/73	US-A-	3568286	09/03/71
		US-A-	3730794	01/05/73
FR-A- 2144809	16/02/73	DE-A,C	2231780	01/02/73
		US-A-	3751551	07/08/73
		US-A-	3879161	22/04/75
		AU-A-	4422572	10/01/74
		GB-A-	1399917	02/07/75
		AU-B-	471855	06/05/76
		CA-A-	1001815	21/12/76
		SE-B-	419957	07/09/81

For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82